A CONSERVATION ASSESSMENT FOR FISHERS (*Martes pennanti*) IN THE SIERRA NEVADA OF CALIFORNIA

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EXECUTIVE SUMMARY

This conservation assessment provides a science-based, comprehensive assessment of the status of the fisher and its habitat. It identifies and evaluates key risk factors affecting viability and describes general Conservation Options that can be used to form the basis of a strategy to conserve and restore populations throughout the current and former range of this species in the Sierra Nevada of California.

Summary of Key Findings

At the bioregional scale, large forested areas with fairly dense canopy cover that provide productive prey habitat appear to be crucial to fisher population persistence across the landscape. Trees with cavities and the presence of suitable denning and resting structures appear to be key resources at the microsite scale within these forested areas. Fully functioning ecological processes of decay and disease are required to develop the selected microsite characteristics over time. Such conditions are generally more prevalent in older forests.

Fishers Occur In Landscapes With Little To No Old-Growth

- Fishers select structural elements for den and rest sites that occur more frequently in old forest habitats; these elements may be lacking in heavily managed landscapes or younger forests. This has led to an inaccurate perception that fishers *require* late successional (old-growth) forests in the west.b
- Fishers occur in managed forested landscapes with little old forest habitat, provided adequate structural elements are present.

Areas Occupied by Fishers Exhibit Ecological Processes Characteristic of Older Forests

- Occupancy of an area by fishers seems to reflect tree species composition, properly functioning ecological processes, and site productivity. These elements provide for protective cover, prey, and resting and denning opportunities in the form of down wood and tree cavities. Forested lands under intensive silvicultural management may no longer support these functions.
- Production of merchantable timber in the west has favored silvicultural practices that simplify forest ecosystems through selective removal of large trees to maximize growth of residual stands, the elimination of snags and coarse woody debris, and the exclusion of non-commercial tree species. When these practices are implemented over very large areas, the ecological functioning of the landscape is impaired.

Females Appear To Be More Habitat Selective Than Males or Juveniles

- In the southern Sierra Nevada, an average of 72 percent of the area within female home ranges was comprised of forested habitats with 60-100 percent canopy cover compared to an average of only 56 percent of the area in 60-100 percent canopy cover within male home ranges.
- The greater habitat selectivity exhibited by female fishers and the need to secure reproductive habitat will form the core of future conservation strategies.

Key Threats to Fisher Persistence in The Sierra Nevada

- Uncharacteristically severe wildfire resulting in loss of suitable habitat at multiple spatial scales.
- Decline in critical structural elements used for resting or denning at microsite and larger scales.
- Fragmentation of habitat preventing dispersal and access to mates (from roads, other sources).
- Anthropogenic sources of mortality affecting individual fishers, and ultimately, populations.

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INTRODUCTION

Purpose of this Assessment

One goal of the Sierra Nevada Forest Plan Amendment Record of Decision (SNFPA ROD's 2001, 2004) was to protect and restore fisher (*Martes pennanti*) populations in the Sierra Nevada. To accomplish this goal, the RODs committed the USDA Forest Service (Forest Service) to complete a conservation assessment for fishers in cooperation with other federal, state, and local agencies, as well as tribal governments. A working group of biologists, research scientists, and resource managers from the Forest Service, National Park Service, U.S. Fish and Wildlife Service, U.S. Geological Survey, California Department of Fish and Game, and consulting firms cooperated to develop this assessment.

Definition of a Conservation Assessment

A conservation assessment synthesizes the best available scientific information and expert opinions concerning habitat relationships, population status and trends, historical and current distributions, and key risk factors likely to affect species distribution and persistence. This document is not intended to be a meta-analysis, or to reanalyze existing data. The intent is to aggregate all known information into a single source that may be used by interested parties to learn about the species, to analyze potential effects of natural and anthropogenic events, and to plan for conservation of the species.

This conservation assessment provides a science-based, comprehensive assessment of the status of fishers and their habitat. It identifies and evaluates key risk factors affecting viability and describes general Conservation Options that can be used to form the basis of a strategy to conserve and restore populations throughout the current and former range of this species in the Sierra Nevada mountain range of California.

This assessment constitutes the first phase in a three-phase process. The second phase is the development of a conservation strategy. The assessment phase provides the information base, scientific foundation, and rationale for the issues and opportunities to be addressed in a conservation strategy. Assessments may be differentiated from strategies in that a strategy utilizes information synthesized by the assessment to analyze risk factors and develop actions designed specifically to mitigate those risks. A strategy develops means to limit discretionary management effects as well as pro-active actions that can be taken to conserve, rehabilitate, and/or restore habitats to support viable, well-distributed populations throughout as much of the historical range as possible. A strategy may also examine the efficacy of translocation or reintroduction of animals to portions of the historical range from which they have been extirpated. Conservation strategies are similar in concept to recovery plans produced for threatened or endangered species under the authority of the Endangered Species Act. The advantage of conservation strategies is that recovery of a species from imperilment may be implemented before the extinction vortex begins to accelerate, thereby decreasing costs and effort to do so.

The third phase in the conservation process is the execution of a multi-agency cooperative conservation agreement. The agreement facilitates implementation of specific conservation actions recommended in the conservation strategy. It functions to coordinate and sequence efforts undertaken by the signatory agencies to maximize conservation value to the species and enhance efficiencies, while simultaneously minimizing participant costs.

Relationship to Other Efforts

Since the inception of this Sierra Nevada Conservation Assessment in 2002, several complimentary projects to describe fisher habitat distribution and status, habitat use, risks, and threats have been initiated. These efforts are being conducted at various spatial scales across the West.

In 2006, The Forest Service, in cooperation with USDI Fish and Wildlife Service (FWS), USDI Bureau of Land Management (BLM), USDI National Park Service (NPS), the states of Washington, Oregon and California, the province of British Columbia in Canada, and the Hoopa tribe began a conservation assessment and strategy for the entire West Coast fisher distinct population segment. The range of habitat used from Canada to the southern Sierra Nevada provides an opportunity to explore the adaptability of fishers in vastly divergent bioregions. This plays out in the form of contextual comparisons of habitat used and in perceived threats and risk. These similarities and differences will provide insight into fisher ecology. The West Coast assessment is anticipated to be available in mid-2008, and the West Coast conservation strategy by 2009.

The Conservation Biology Institute (CBI) (www.consbio.org), located in Corvallis, Oregon, entered into an agreement with the Forest Service in 2006 to conduct a specific fisher analysis. The numerical extent of extant fisher populations in the southern Sierra Nevada (Sequoia, Sierra and Stanislaus National Forests) is being analyzed and estimated. Additionally, habitat quality, quantity and distribution are being mapped as part of the CBI Fisher Baseline project. Another anticipated product of this analysis is a landscape-scale predictive model to be used in assessing the effect of management actions on fisher habitat and populations. The map product final report will be available in January 2008, and the management effects model results are anticipated for summer 2008.

The Pacific Southwest Research Station of the Forest Service initiated a study of fishers in the King's River Project area of the Sierra National Forest in 2007. This research is designed to collect data on vital rates (reproduction and mortality), investigate dispersal, and illuminate the impact of natural and anthropogenic disturbances on foraging and habitat use (Thompson and Purcell 2007). This study will attempt to mimic the methodology of the Sierra Nevada Adaptive Management Project (SNAMP - see below for description). The goal is to use these two studies as replicates of a larger regional research effort to clarify the influence of landscape heterogeneity on dispersal of fishers and population dynamics (Thompson and Purcell 2007).

The Sierra Nevada Adaptive Management Project was initiated to develop, implement and test Adaptive Management processes by investigating the efficacy of Strategically Placed Landscape [Vegetation] Treatments (SPLATs) across four response variables: public participation, wildlife, water, and fire/forest health. SNAMP is composed of researchers from the University of California, the University of Minnesota, the U.S. Forest Service (USFS), the California Resources Agency, the U.S. Fish and Wildlife Service, and the Public. The Science Team is working with the agencies to develop an adaptive management and monitoring program consistent with the Sierra Nevada Forest Plan Amendment (USDA Forest Service 2001, USDA Forest Service 2004).

The primary question being evaluated is whether the population of fishers in the treatment area will exhibit decreased viability over time. The metrics employed to measure the response are population trend, reproductive performance, survival, and dispersal success as a result of lowered habitat quality (University of California 2007). The SNAMP project will employ the habitat model developed by the CBI Fisher Baseline Project discussed above.

The Forest Service has personnel involved in each of these projects, working to provide consistency between efforts. This also ensures availability of the most current information and scientific thinking regarding fishers and their habitat.

How Agency Biologists Can Use This Conservation Assessment

Field biologists and managers are encouraged to use the information contained herein for project planning and analysis. In effects analyses, document the full spectrum of habitat associations in California, then focus on study results and data closest to the geographic location of the proposed project to evaluate effects of proposed management activities. Wherever possible, original literature should be reviewed and cited, rather than a summary document such as this assessment, except where such an assessment provides data or study comparisons to generate new information.

The National Environmental Policy Act of 1970 (NEPA) and implementing regulations provide specific direction for the procedure to incorporate information by reference into analyses. It is not sufficient to state that all information contained in a document is incorporated. A summary of relevant data must be prepared and included in the project evaluation document.

Clearly list the assumptions and limitations associated with cited research to ensure proper contextual use of study inferences or conclusions. When doubt exists regarding proper interpretation of results, readers are encouraged to contact study authors directly, or discuss projects being planned with respected local fisher experts. When such contact results in a “personal communication” citation in an analysis document, it is wise to request review of any resultant text by the expert being cited to ensure accuracy and supportability.

APPROACH

Scope of the Assessment

Organization of the Assessment

The document is organized under the following key headings:

- Ecology
- Conservation Status
- Risk Factors
- Conservation Options

The Ecology section provides not only the life history information required to understand the unique ecology of Sierra Nevada fishers, but it also provides that scientific support and rationale for future management strategies. The Conservation Status section explains the political drivers for conserving fishers, as well as identifying the past factors that resulted in the current population status, while the Risk Factors section identifies those factors that may still be operating today, and must be overcome to successfully conserve or restore fisher populations in the future. Finally, the Conservation Options section synthesizes information from the previous 3 sections into a set of management information needs and approaches designed to conserve and restore fisher populations in the Sierra Nevada. These Conservation Options are considerations that form the nucleus of the Conservation Strategy, the second step in the conservation process. Besides launching a Forest Service-led conservation strategy, the assessment provides guidance for field biologists as they evaluate potential effects of land and resource management projects on fisher populations, identifies habitat restoration opportunities on private and government lands, and provides the textbook for multiple agencies, conservation groups, and private landowners to begin a coordinated effort towards conservation of fishers in the Sierra Nevada.

Geographic Scope of the Assessment

The mandate for this fisher conservation assessment is to address the ecology and conservation status of fishers within the SNFPA planning area (National Forests within the Sierra Nevada and Modoc Plateau Bioregions). However, to adequately address the ecology, distribution, and status of fishers within the planning area, it is necessary to place fisher populations in a larger geographic context. Thus, Sierra Nevada fisher populations are compared and contrasted with populations elsewhere in California (e.g., north coast and Shasta-Trinity National Forest), expanded to its relationship with West Coast populations in Oregon and British Columbia, and then finally across its entire range.

Objectives

Objectives for this assessment include the following:

1. Summarize existing research, current scientific knowledge, and expert opinion about the ecological conditions necessary to provide well-distributed, self-sustaining populations of fishers in the Sierra Nevada mountains of California,
2. Summarize current knowledge about the status of the species in the Sierra Nevada Bioregion in the context of fisher populations in the Pacific states and British Columbia,

3. Identify and evaluate the relative importance of risk factors that may be affecting the species or its habitat,
4. Develop considerations for species conservation to carry forward into a conservation strategy, including the rationale for Conservation Options, and
5. Summarize existing research and identify key information gaps.

Standards for Knowledge

Although fishers have been a species of conservation concern in California, and especially the Sierra Nevada, since Grinnell et al.'s (1937) landmark publication, only recently has research attention focused on this species in California. Other than Grenfell and Fasenfest's (1979) diet studies in the 1970s, and thesis habitat studies in the 1980s by Buck (1982) and Mullis (1984), all in northern California, prominent California fisher research has occurred only since the 1990s. The early 1990s saw a profusion of studies in the Klamath, Siskiyou, and north coast ranges (Self and Kerns 1992, Seglund 1995, Beyer and Golightly 1996, Carroll 1997, Dark 1997, Golightly 1997, Klug 1997, Higley et al. 1998, Carroll et al. 1999), with a number of studies initiated in the Sierra Nevada in the mid-1990s (Zielinski et al. 1995, 1997a, 1997b, 1997c, 1999, 2000, 2004a, 2004b; Krohn et al. 1997; Boroski et al. 2002; Truex et al. 1998; Lamberson et al. 2000; Mazzoni 2002; Campbell 2004; Zielinski and Duncan 2004). Currently, research is also being conducted on lands owned by Green Diamond Resource Company, Sierra Pacific Industries, and the Hoopa Valley Indian Reservation. Research in the southern Sierra Nevada continues by scientists from the University of California, Berkeley; Humboldt State University, and the USDA Forest Service Pacific Southwest Research Station. Figure 1 (and accompanying Table 1) shows the locations of past and current research projects on fishers in California.

Although this conservation assessment focuses on the Sierra Nevada, by necessity information from other California populations, and populations throughout the fisher's North American range, are presented where it contributes to our understanding of Sierra Nevada populations, but is caveated where appropriate. Consequently, all "best science" available is incorporated into this assessment to ensure the highest standards of knowledge.

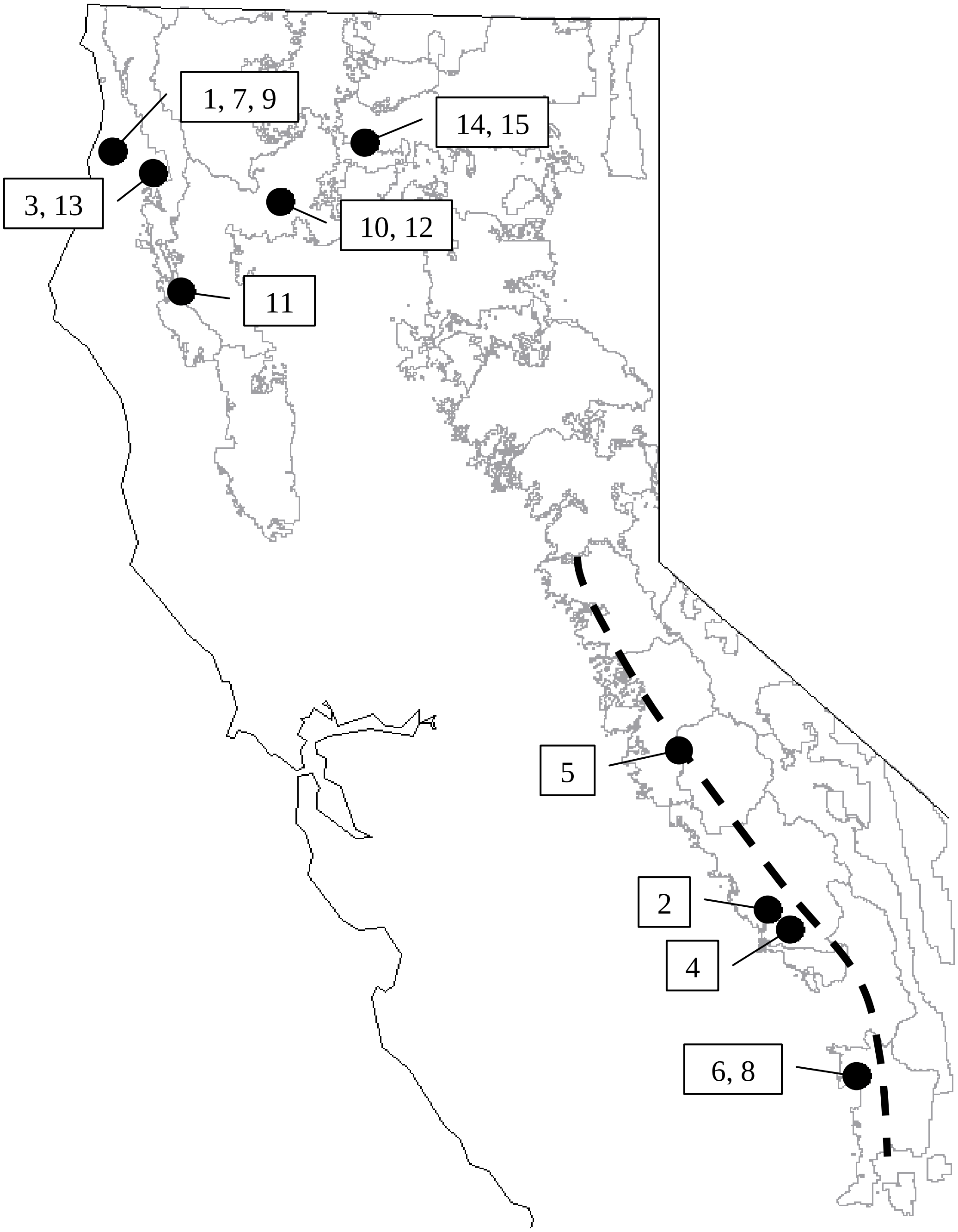

Figure 1. **Distribution of intensive research projects for fishers (*Martes pennanti*) in California, 1990-2004. See Table 1 for map ID key.**

Table 1. List of Recent Research Projects in California

Map ID	Ecoregion	Study Area Name	Data Collected	Principal Investigator(s)	Affiliation	Location
1	Northern Calif. Coast	Green Diamond Resource Co.	2002 - present	Joel Thompson, Lowell Diller & Rick Golightly	Green Diamond Resource Co.	private land: Humboldt & Del Norte Counties
2	Southern Sierra	Kings River	2001 - present	Mark Jordan & Reg Barrett	UC Berkeley	Sierra NF: Fresno County
3	Klamath-Siskiyou	Hoopa Valley	2000 - present	Scott Yeager, Mark Higley & Rick Golightly	HSU, Hoopa Valley Tribe	Hoopa Valley Indian Reservation: Humboldt County
4	Southern Sierra	Kings River	1999 – present	Amie Mazzoni, Brian Boroski & Kathy Purcell	PSW, Fresno; CSU Fresno	Sierra NF: Fresno County
5	Central & Southern Sierra	CSN/SOSI	1996 – 1999	Lori Campbell et al.	UC Davis	Tahoe, Eldorado, Stanislaus, Sierra and Sequoia NFs, Giant Sequoia NM, Yosemite NP, Sequoia-Kings Canyon NP, private land: Placer, El Dorado, Amador, Calaveras, Tuolumne, Mariposa, Madera, Fresno, Tulare & Kern Counties
6	Southern Sierra	SOSI	1996 - 1999	Rick Truex, Reg Barrett	PSW, RSL; UC Berkeley	Sierra & Sequoia NFs, Giant Sequoia NM, Sequoia-Kings Canyon NP, Tule River Indian Res., Mtn. Home State Forest: Fresno, Tulare & Kern Counties
7	Northern Calif. Coast	Green Diamond Resource Co.	1996 - 1998	Keith Hamm, Lowell Diller & Rick Golightly	Green Diamond Resource Co.	private land: Humboldt & Del Norte Counties
8	Southern Sierra	Southern Sierra	1994 - 1996	Bill Zielinski, Rick Truex et al.	PSW, RSL	Sequoia NF, Giant Sequoia NM: Tulare County
9	Northern Calif. Coast	Green Diamond Resource Co.	1994 - 1995	Rich Klug, Lowell Diller & Rick Golightly	Green Diamond Resource Co.	private land: Humboldt & Del Norte Counties
10	Klamath	Shasta-Trinity	1994 - 1995	Shawna Dark & Rick Golightly	Humboldt State Univ.	Shasta-Trinity NF: Shasta & Trinity Counties
11	North Coast Range	North Coast	1993 - 1997	Bill Zielinski et al.	PSW, Redwood Sciences Lab	Six Rivers NF: Humboldt & Trinity Counties
12	Klamath	Trinity	1992 - 1994	Amy Seglund & Rick Golightly	Humboldt State Univ.	Shasta-Trinity NF: Trinity County
13	Klamath-Siskiyou	Hoopa Valley	1990 - present	Mark Higley et al.	Hoopa Valley Tribe	private land: Humboldt County
14	Klamath	Castle Ck./Buck Mtn.	1990 - 1993	Steven Self & Steven Kerns	Sierra Pacific Industries	private land: Siskiyou County
15	Klamath / Southern Cascades	Sierra Pacific Industries	1990 - 1991	Steven Criss & Steven Kerns	Sierra Pacific Industries	private land: Trinity, Shasta, Lassen & Siskiyou Counties

ECOLOGY

Description and Taxonomy

Fishers are mesocarnivores of the family Mustelidae (subfamily *Mustelinae)* in the genus *Martes*. The only other extant North American member of this genus is the smaller American marten (*Martes americana*) (a possible third *Martes* species, the noble marten [*M. nobilis*], is extinct, but did survive to the late Holocene and may have interacted with the other two extant species [Grayson 1984]). Both fishers and martens possess morphological adaptations such as high shoulder mobility and recurved claws to aid in arboreal movement, lengthening of distal limb bones, and a plantigrade stance that facilitates travel across large home ranges (Powell and Zielinski 1994, Buskirk 1994; see Powell et al. 2003). Three subspecies of fishers are recognized: *M. p. pennanti*, eastern North America and south to North Carolina; *M. p. columbiana*, British Columbia east to northern Manitoba; and *M. p. pacifica*, British Columbia south to California (Goldman 1935, Hall 1981). Although there is some controversy regarding the distinctness of these three subspecies (Powell and Zielinski 1994), current management practices recognize Pacific fishers as a unique subspecies, and the U.S. Fish and Wildlife Service recently concluded that the West Coast fisher population warrants status as a "distinct population segment" based on genetic distinctness (Wild and Roessler 2004).

Fishers exhibit the elongated body plan characteristic of most members of the *Mustelidae*. They are covered in grizzled brown or black hair with white patches on their chests and abdomens. Fishers are sexually dimorphic: males are generally one meter (m) long and weigh about 3.5-5.0 kilograms (kg), while females average 80 centimeters (cm) in length and weigh 2.0-2.5 kg (Powell 993). Zielinski et al. (1997a) found fishers in the southern Sierra Nevada to average smaller than eastern populations (males approximately three kg and females two kg).

Distribution

Fishers are found in forests and woodlands of North America, from the mountainous areas in the southern Yukon and Labrador provinces of Canada southward to central California, Wyoming, the Great Lakes and Appalachian regions, and New England (Nowak and Paradiso 1983). The Pacific subspecies (*M. p. pacifica*) was historically distributed throughout coniferous forest landscapes from British Columbia south to California. Currently, in California, *M. p. pacifica* occurs in the northern Coast Ranges and Klamath Province at elevations near sea level to about 1,700 m (5,600 ft) (Golightly et al. 2006) and occurs sympatrically with the marten in the southern Sierra Nevada (Stanislaus, Sierra, and Sequoia National Forests; Yosemite and Sequoia/Kings Canyon National Parks; and Giant Sequoia National Monument), at elevations of 1,500 to 2,130 m (4,900 to 7,000 ft) in mixed conifer forests (Zielinski et al. 1997a), although they do occur alone to 1,000 m (3,280 ft; Golightly et al. 2006). Fishers historically occurred in the northern and central Sierra Nevada (Lassen, Plumas, Tahoe, Lake Tahoe Basin, Eldorado National Forests) (Grinnell et al. 1937), but were not known to occur in the far eastern limits of the Sierra Nevada (Inyo or Humboldt-Toiyabe National Forests) or the Modoc Plateau (Grinnell et al. 1937; Figure 2).

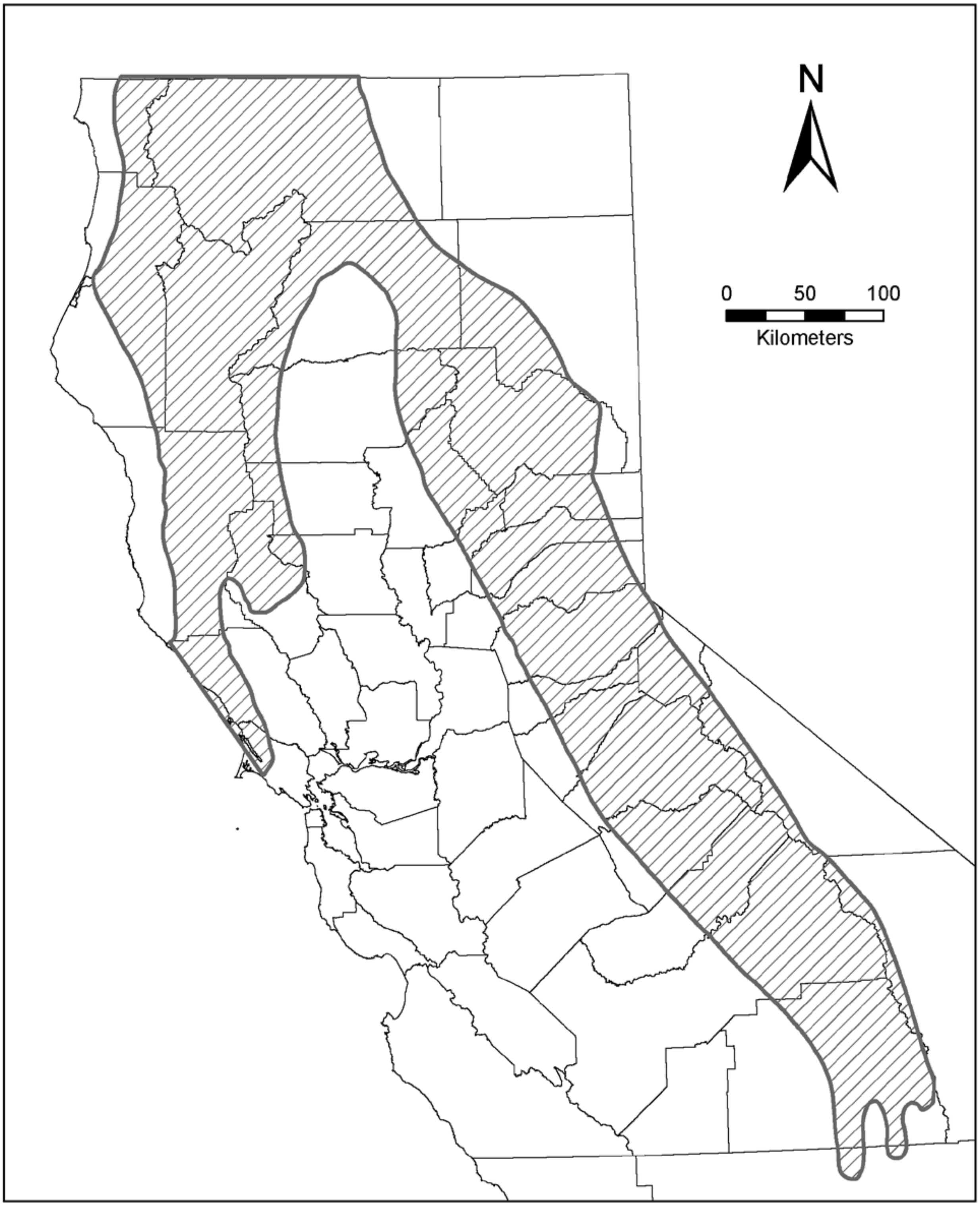

Figure 2. Historical distribution of fishers in California based on Grinnell et al. (1937).

Overtrapping and habitat alteration have led to population declines and extirpation throughout much of their range in the Pacific states (Douglas and Strickland 1987; Zielinski et al. 1995, 2005; Lewis and Stinson 1998), although predator and rodent control programs also played a role (Aubry and Lewis 2003, Wild and Roessler 2004). Fishers appear to be extirpated from central and northern Oregon and all of Washington (Aubry and Lewis 2003). From the 1960s to the 1980s, a series of reintroductions were attempted in Oregon, with mixed success, using fishers from British Columbia and Minnesota (Aubry and Lewis 2003). Extant populations of fishers in southern Oregon appear to persist in two disjunct populations, one in the southern Cascades and one in the northern Siskiyou Mountains (Aubry and Lewis 2003, Aubry et al. 2004). Genetic analysis has demonstrated that the population in the southern Oregon Cascades was the likely result of reintroductions from British Columbia and Minnesota (Drew et al. 2003), while the Siskiyou Mountains population is the northern extension of the indigenous population centered in the Klamath province of California (Aubry et al. 2004, Wisely et al. 2004).

California fishers also have experienced a dramatic range contraction (Zielinski et al. 1995, 2005). Although they historically occurred throughout the Sierra Nevada, the current distribution of fishers in California consists of two distinct populations separated by more than 400 kilometers (km): the combined coastal and inland population of northwestern California and the southern Sierra Nevada population (Zielinski et al. 1995). Recent systematic surveys (Figure 3) indicate that fishers are absent from their former range in the central and northern Sierra Nevada, northward of Yosemite National Park to the southern Cascade Range (Zielinski et al. 1995, 2005), and now occupy less than half their historical Sierra Nevada range. This gap in distribution effectively isolates the existing southern Sierra Nevada population from extant populations in northern California and southern Oregon. A regional monitoring program (Zielinski and Mori 2001) continues to monitor for the presence of fishers throughout the Sierra Nevada. Annual reports from 2002 to present are available through the Forest Service Regional Office or any Forest Service office in the Sierra Nevada.

Genetic Isolation

With the loss of fishers in central and northern Oregon, and all of Washington, both California populations are effectively isolated from the nearest indigenous populations in British Columbia (Aubry and Lewis 2003, Drew et al. 2003). Recent genetic analysis provides evidence that fisher populations from British Columbia to California were once connected (Drew et al. 2003), but the California populations now exhibit high genetic structuring and low genetic diversity (caused by population fragmentation and isolation) suggesting increased vulnerability of extinction (Wisely et al. 2004). The high level of structure is illustrated by the genetic differentiation between two adjacent southern Sierra Nevada populations, separated by less than 100 km of forested habitat and the Kings River (Wisely et al. 2004).

Genetic studies in the southern Cascade range (Aubry et al. 2004) showed a marked relatedness among female fishers, implying that female fishers do not disperse far from where they were born; thus female phylopatry could account partly for the high genetic structuring and apparent low gene flow found in the southern Sierra Nevada (Wisely et al. 2004). Genetic differentiation between the two southern Sierra populations suggest an average population exchange of only one migrant every 50 generations (Wisely et al. 2004), a rate which is probably now greatly exacerbated by human-induced changes in the forest landscape. Population isolation combined with reduced gene flow increases the southern Sierra population’s vulnerability to extinction (Gilpin and Soule 1986, Wisely et al. 2004).

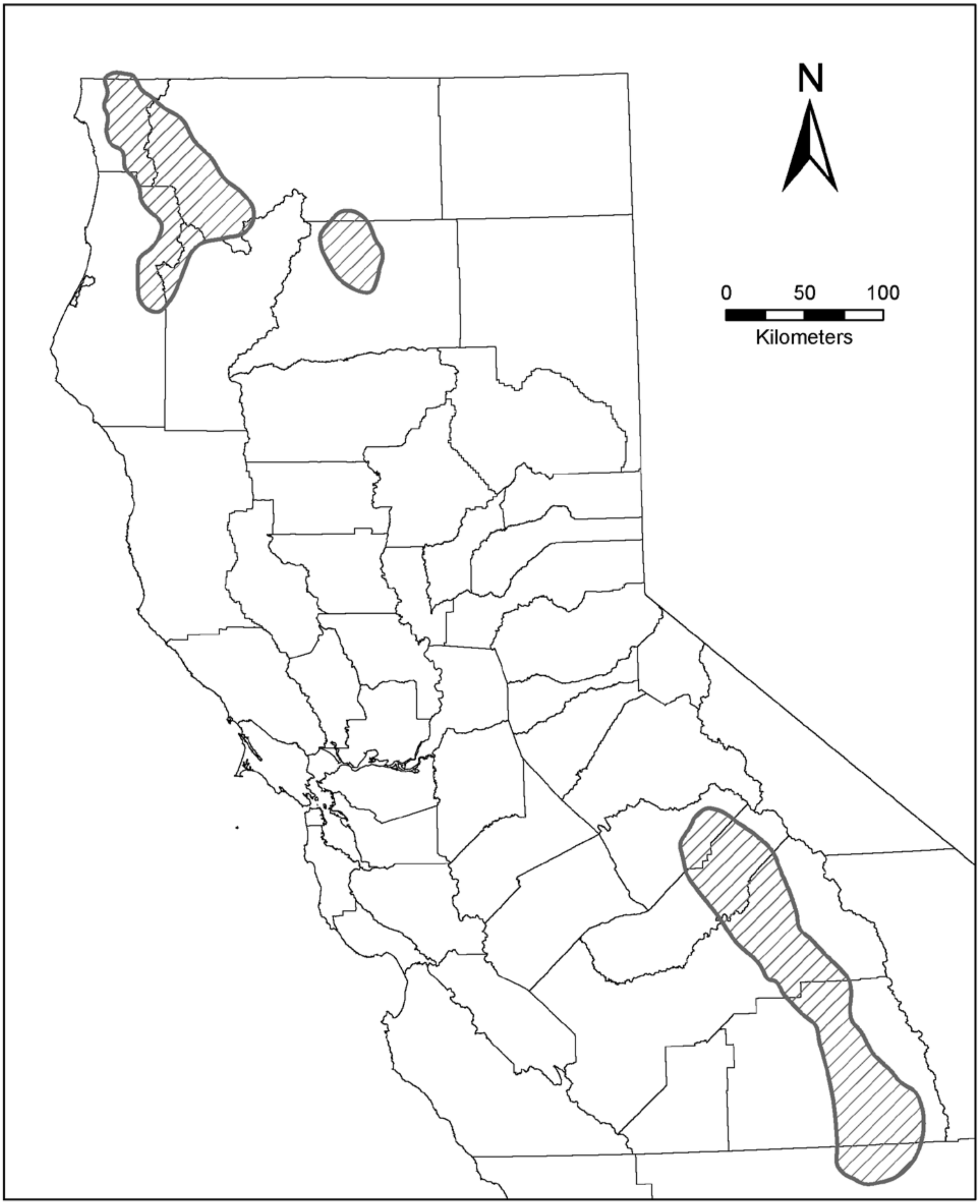

Figure 3. Current distribution of fishers in the Sierra Nevada and elsewhere in California based on Zielinski (1995a, 2005).

POPULATION ECOLOGY

Density and Population Estimate

Because fisher population densities are low compared to other terrestrial animals, confident density estimates are difficult to obtain (Powell and Zielinski 1994, Lewis and Stinson 1998). This is especially true in the Pacific states where fisher populations are greatly depleted. Nevertheless, some estimates are available for California. Zielinski et al. (2004b) estimated approximately five female fishers per 100 square kilometers (km^2) in their north coast study area, and eight females per 100 km^2 in the southern Sierra Nevada. Lamberson et al. (2000) modeled fisher population viability and estimated that there were between 100 and 500 individuals in the southern Sierra population. Regardless how imprecise these estimates might be, extant fisher populations are likely small based on habitat reduction and the lack of detections (Wild and Roessler 2004). As a comparison, studies in the northeastern U.S. found population densities between 25 (Fuller et al. 2001) and 38 (Arthur et al. 1989a) fishers per 100 km^2, and similar high densities may be found on the Hoopa Valley Reservation (northwestern California) based on the small home ranges found there (Yeager 2005). In contrast, Weir (2003) provided density estimates of only 6.8 fishers per 1,000 km^2 for *M. p. pacifica* populations in British Columbia.

Survival and Mortality

Very little data exist on age-specific survivorship rates for fishers, although there is some anecdotal information (Table 2). Age-specific survivorship of fisher populations appears to fluctuate with prey populations. During periods of high prey availability, juvenile fishers comprise a higher-than-average proportion of a trapped population. When prey populations are low and fisher populations decline, cohorts of old fishers comprise higher-than-average proportions of the population (Douglas and Strickland 1987, Powell 1994a). Harvested populations (eastern North America) of *Martes* species tend to be biased towards young animals, on the average, compared to unharvested populations (Powell 1994a). The relevance of this information to unharvested populations in California is unknown.

Table 2.—Age-specific Survivorship of Fishers

Mean Survival Rate-Trapping Season				Mean Survival Rate-Non-Trapping Season				
Juvenile Males	**Juvenile Females**	**Adult Males**	**Adult Females**	**Juvenile Males**	**Juvenile Females**	**Adult Males**	**Adult Females**	**Author**
0.39	0.34	0.57	0.79	0.71	0.75	0.89	0.87	Krohn et al. 1994[1]
						0.73[2]	0.61[2]	Truex et al. 1998
						0.73[3]	0.86[3]	Truex et al. 1998
						0.84[4]	0.84[4]	Truex et al. 1998
						0.85[5]	0.78[5]	Aubry and Raley 2006
							0.72[6]	Higley and Matthews 2006

1 = Trapped population in Maine.
2 = Non-trapped population in the southern Sierra Nevada.
3 = Non-trapped population in the eastern Klamath area of California.
4 = Non-trapped population in the northern coast range of California.
5 = Non-trapped population in the Oregon Cascades.
6 = Non-trapped population in northwestern California.

Few data exist on mortality rates for fishers, especially for untrapped populations. The only data that compare juveniles with adults are based on trapped populations where trapping is the primary cause of death in fishers. Krohn et al. (1994) studied a commercially exploited population in Maine and found that, outside the winter trapping season, adult fishers had average mortality rates of 11 percent, while juvenile mortality rates were two to three times higher and more variable. Truex et al. (1998) studied an

unexploited population in the southern Sierra Nevada and found that males had higher mortality rates than females.

Age Structure and Sex Ratio

Accurate estimates of age structure in wild fisher populations are difficult to obtain because almost all information come from trapping data (commercial or research), and the trappability among age classes and between sexes varies greatly. Harvested populations of *Martes* in general are skewed towards younger animals as few individuals survive to older ages under the trapping pressure (Strickland and Douglas 1987, Powell 1994a). In a harvested population in Wisconsin, Kohn et al. (1993) found 91 percent of 919 commercially harvested fishers were less than three years of age, and in British Columbia, 95 percent of trapped animals were under the age of five years (Weir 2003). Although the maximum life span of wild fishers is approximately 10 years (Kohn et al. 1993, Powell 1993), and Weir (2003) reported a harvested female of 12 years, fishers seven years and older composed only two percent of the harvested animals in Kohn et al.'s (1993) study, and less than one percent in Weir's (2003) study. The bias towards younger animals can also reverse with declining prey populations. Lower food supplies equates to fewer juveniles produced, skewing the age structure towards older age classes.

Males are also apparently more susceptible to trapping than females (Strickland and Douglas 1981, Buskirk and Lindstedt 1989, Krohn et al. 1994), probably because their larger and shifting home ranges could increase trap encounter (Krohn et al. 1994). Male movements become more extensive during the mating season, which can coincide with the trapping season. In Maine, Krohn et al. (1994) found that male fishers are twice as likely as females to be trapped. Numerous other studies (Quick 1953, Hamilton and Cook 1955, Coulter 1966, Kelly 1977, Strickland 1978, Berg and Kuehn 1994, Truex et al. 1998) have also shown that in harvested populations adult sex ratios are biased towards females. Powell (1993) surmised that in an unharvested population, sex ratios of adults are roughly 50:50; this supposition is supported by Krohn et al.'s (1994) results that indicated outside the winter trapping season, male and female fishers in Maine had equivalent mortality rates. However, the spatial organization of fishers suggests that there should be more females, given that several female home ranges may overlap a single male home range (Arthur et al. 1989a, Weir 2003). In general, accurate age structure estimates are confounded by data collection means (mainly trapping), impacts from harvest (biased mortality), and environmental vagaries (e.g., changing prey populations).

Reproduction

The reproductive biology (but not necessarily the schedule) of female fishers is similar to that of many other mustelids (Mead 1994). Female fishers are sexually mature and can breed for the first time at one year of age (Douglas and Strickland 1987). Ovulation is presumably induced by copulation (Douglas and Strickland 1987). Implantation is delayed approximately 10 months; therefore, female fishers can produce their first litters at age two. Females breed again approximately one week following parturition (Hall 1942, Powell 1993, Frost and Krohn 1997).

From mid-March through April, all adult males appear to be fully sexually active. Despite having sperm, one-year-old male fishers do not appear to be effective breeders, possibly because baculum development is incomplete (Strickland et al. 1982). Coulter (1966) reported that eastern male fishers began to increase their movement rates and distances traveled beginning in March, while Aubry and Raley (2006) found southern Oregon male fishers to begin these presumably breeding movements in early February. These movements result in males trespassing on the territories of other males, and they may fight with other males while competing for access to females (Leonard 1986). The first visible signs of estrus in female fishers is the enlargement of the vulva (Mead 1994), and females are in estrus for about

six to eight days, beginning three to nine days following parturition for adult females (Hodgson 1937). Douglas and Strickland (1987) summarized the breeding season for fishers to be February 27 to April 15, based on known birth dates of captive litters, but this ignored the three- to nine-day delay between parturition and breeding. Implantation can occur as early as January and as late as early April (Coulter 1966, Hodgson 1937).

Parturition dates have been recorded as early as February and as late as May (Coulter 1966, Hodgson 1937). In British Columbia, parturition dates ranged from March 23 to April 10 (Hall 1942, Weir 2000), while Higley and Matthews (2006) reported earlier parturition dates for northern California fishers ranging from March 9 to 4 April. Thus, an adult female fisher is pregnant almost all the time, except for a brief period following parturition. Gestation varies from 327 to 358 days with a mean of 352 days (Hall 1942). The period of active pregnancy, following implantation, has been variously reported as from 30 days (Coulter 1966) to about two months (Hamilton and Cook 1955).

Across their geographic range, fishers produce reported averages of between two and four young per adult female (Strickland et al. 1982, Powell 1993, York 1996, Frost and Krohn 2004), although recent research on west coast populations indicate smaller average litters (1.9, Aubry and Raley 2006; 1.8, Higley and Matthews 2006) for *M. p. pacifica*. Coulter (1966) found that young weighed about 40 grams (g) at birth, and growth was rapid (5-10 g/day), so that by 96 days they weighed over 800 g. The young were relatively helpless until about the sixth or seventh week. They started crawling in the eighth week, when their eyes opened. They were walking during the ninth week and climbing during the tenth week. The adult did not take meat to the young until they were 62 days old, by which time the deciduous canine teeth had erupted. Nursing continued until the 114th day. The young were 125 days old before they learned to kill prey effectively (Coulter 1966). Juvenile fishers in the Oregon Cascades became independent of their mothers at about seven months of age and had settled into established home ranges at about one year (Aubry and Raley 2006). Adult males apparently take no part in the rearing of the young (Strickland et al. 1982).

Habitat Relationships

General

In the Southern Sierra Nevada, fishers largely occupy low to mid-elevation forests (1,500 to 2,100 m) where deep snow is rare (Mazzoni 2002, Zielinski et al. 1997a). Habitat structures used for denning, resting, and prey habitat seem to occur most frequently in this elevation range. Habitat selected by fishers can generally be described as conifer or conifer-hardwood mixed forests with continuous overhead canopy coverage (Powell 1993). Forest type is probably not as important to fishers as the vegetative and structural aspects that create resting and denning sites, lead to abundant prey populations, and reduce vulnerability of fishers to predation (Powell 1993). Fishers use many forest types and predictors of use vary with spatial scale. The best biotic predictors of fisher occurrence at the landscape or bioregional scale appear to be expanses of forested habitat with moderate to high amounts of canopy cover (Zielinski et al. 2004b). Abundance of suitable den and rest structures as well as prey species availability appears to determine habitat use by fishers at smaller spatial scales (Mazzoni 2002, Zielinski et al. 2004a).

In general, fishers use forest or woodland landscape mosaics that include conifer-dominated stands, and they avoid entering open areas that have no overstory or shrub cover (Buskirk and Powell 1994). They select forests with fairly dense canopies at all spatial scales, and large trees, snags, and downed logs. A vegetated understory and large woody debris appear to be important for their prey species. In the eastern U.S., late-successional coniferous or mixed forests are believed to provide the most suitable fisher habitat because they provide an abundance of potential den sites and preferred prey species (Allen 1987), although managed forests with large trees, dense canopies, and understory structure are also used in California (Klug 1997, Self and Kerns 1992). Riparian areas may be important to fishers because they often provide concentrations of important rest site elements, such as trees with broken tops, snags, and coarse woody debris, as well as habitat corridors for movement (Seglund 1995), although the value of riparian as compared to upland habitats is incompletely understood. The potential value of forested riparian habitat varies in the west, but seems high in the relatively dry Sierra Nevada.

In California, several studies have investigated habitat use by fishers. Studies in the southern Sierra Nevada (e.g., Mazzoni 2002, Zielinski et al. 2004a) showed that a significant, although not large, percentage of home range area was composed of stands of large trees generally greater than 61 cm diameter breast height (dbh) and relatively dense canopy coverage (>50 percent). Forest stands with intermediate tree size (21-61 cm dbh) combined with dense canopy coverage were the dominant forest structure in both studies.

It should be noted that most studies used concave spherical densiometers to measure "over-fisher" (looking upward) canopy cover at specific points of interest such as rest or den sites. Canopy cover measured by this technique differs in a yet-to-be-quantified manner from canopy cover as measured by aerial photointerpretation or geographic information system (GIS) interpretation of satellite imagery (looking downward).

The fact that fishers select structural elements for denning and resting that are commonly found in old forest habitat but may be lacking in heavily managed landscapes or younger forests has led to an inaccurate perception that fishers *require* late-successional forests in the west. Fishers occur in landscapes with little to no late-seral forest. In northern California, fishers have been detected more often in mid-seral forests. Slauson et al. (2003) found that even in coastal areas with high amounts of old-growth habitat, second-growth redwood forests were most often used. Zielinski et al. (2004a) also found mid-seral conifer forest to dominate home ranges in coastal northern California, and Carroll et al. (1999) found

the distribution of fishers in northern California was strongly associated with high levels of canopy closure. In studies of fisher habitat use on industrial timberlands, Self and Kerns (1992) and Klug (1997) found that mid-seral stands with denser canopies were most often used by fishers. Self and Kerns (1992) also found fishers selecting older-aged stands with relatively sparse canopy closures, but where an associated heavy shrub component contributed to the overall canopy closure.

Stands with continuous dense canopy coverage are important to fishers probably because they provide protection from avian predators and intercept snow. Fishers have been reportedly killed by hawks, eagles, and great horned owls (*Bubo virginianus*) (Douglas and Strickland 1987, Roy 1991). Dense canopy coverage may also protect preferred fisher prey from avian predators as well. Fishers reportedly avoid deep snow because it inhibits their mobility (Raine 1983), and winter snow depth may limit fisher distributions (Krohn et al. 1995, 1997). Both Self and Kerns (1992) and Jones and Garton (1994) noted a shift towards use of younger age stands in the winter, which may reflect both an increased prey availability and greater snow interception. Despite the reason for selecting stands with higher canopy coverage, many studies have shown that fishers avoid areas with little forest cover (Powell 1977, Jones 1991, Arthur et al. 1989a, Weir and Harestad 2003).

As elsewhere in the fisher's range (Powell 1993, Buskirk and Powell 1994), California studies have noted hardwoods to be an important component of fisher habitat (Self and Kerns 1992, Klug 1997, Zielinski et al. 2004a), especially California black oak (*Quercus kelloggii*). Hardwood habitats probably are important to fishers because they provide habitat and food for important prey species. Where mast production is high, small fisher home ranges and/or high densities suggest that oak may be an important component of fisher habitat. Oak trees also provide important rest and den sites both in the southern Sierra Nevada (Zielinski et al. 2004b) and northern California (Self and Kerns 1992, Higley et al. 1998, Zielinski et al. 2004b, Yeager 2005). Buck et al. (1994), however, cautioned that forest practices resulting in the conversion of conifer-dominated forest to hardwood-dominated forest is probably detrimental to fishers, because of the loss of denser canopy structure.

At a landscape scale, patches of preferred habitat and the location of open areas with respect to these patches may be critical to the distribution and abundance of fishers in an area (Buskirk and Powell 1994). Fishers will probably use patches of preferred habitat that are interconnected by other forest types, whereas they will not likely use patches of habitat that are separated by sufficiently large open areas (Rosenberg and Raphael 1986, Buskirk and Powell 1994). Assessing the effect of forest fragmentation on fishers in northwestern California using baited track plates, Rosenberg and Raphael (1986) found fishers to be negatively associated with clearcuts and forested stands significantly edged by clearcuts. They also found fishers to more likely be detected in larger stands (>50 hectares [ha]) than small stands, especially stands with high connectivity. Besides fragmentation due to timber harvest, Sierra Nevada fishers may also face other connectivity barriers including large rivers and highways.

Habitat occupancy by fishers seems to be a function of ecological processes common in older forests. Occupancy of an area by fishers seems to reflect species composition, ecological function, and site productivity. These elements provide protective cover, prey, and substrates in the form of down wood and tree cavities for resting and denning. Forestlands under intensive silvicultural management may no longer be capable of supporting these functions. Historical production of merchantable timber in the west has favored silvicultural practices that simplify forest ecosystems via selective removal of large trees, selected valuable species, and the elimination of snags and coarse woody debris. Implemented across large areas, these practices impair the ecological function of the landscape.

In general, fishers occupy habitats with moderate to high canopy closure, large trees, large woody debris, large snags and hardwoods, and multiple canopy layers (Buck et al. 1994, Buskirk and

Powell 1994, Powell and Zielinski 1994, Seglund 1995, Weir and Harestad 2003, Zielinski et al. 2004b). In western forests these attributes are generally found in late successional stands (Harris et al. 1982, Rosenberg and Raphael 1986, Jones 1991, Buck et al. 1994, Weir and Harestad 2003). However, fishers will use mid-seral and managed forest habitats where the above attributes are provided, especially for foraging (Jones 1991, Roy 1991, Self and Kerns 1992, Jones and Garton 1994, Weir 1995, Klug 1997, Ewald 2003). Intensively managed forests, however, lacking large trees, large woody debris, and large patches of closed forest, especially those fragmented by large clearcuts, will not likely provide the habitat elements found in mature forests (Buck et al. 1994, Powell and Zielinski1994).

Resting and Denning Sites

Powell and Zielinski (1994) and Zielinski et al. (2004b) have suggested that habitat suitable for resting and denning sites may be limited and that these habitats should be given more weight than foraging habitats when planning habitat management. Outside of the breeding season, rest site selection may be one of the most critically important fisher decisions (Zielinski et al. 2006). Resting sites function to protect fishers from predators and aid in thermoregulation during unfavorable weather conditions (Kilpatrick and Rego 1994, Zielinski et al. 2004a). In the southern Sierra, Zielinski et al. (2004b) examined 360 resting structures and found cavities in living oaks to be the most commonly used structure followed by cavities in conifer snags, live conifer trees, and logs, and platforms (such as raptor nests or dwarf mistletoe brooms). Compared to other studies in California, this live oak use is relatively high and may reflect the more southern latitude of Zielinski et al.'s south Sierra study site. In contrast, Zielinski et al. (2004b) found coastal northern California fishers (191 structures measured) to favor live conifers, conifer snags, and platforms over hardwoods and logs. In both regions, fishers generally selected resting sites from the largest available. Live conifers averaged 117 cm dbh, conifer snags 120 cm dbh, and hardwoods 69 cm dbh (Zielinski et al. 2004b). Selected logs were also among the largest available. These larger diameter structures were selected probably because of the greater frequency of cavities they provide compared to younger trees. Trees providing platforms were smaller on average (71 cm dbh) than snags used as rest sites. Males were found to use platforms more than females, probably because the smaller females can use a greater size range of cavities, and may need the greater protection cavities afford.

Other California rest site studies (Seglund 1995, Mazzoni 2002, Yeager 2005) were not appreciably different from Zielinski et al.'s (2004b) results, other than Seglund (1995) and Mazzoni (2002) that found live conifers (84 and 86 percent, respectively), not live hardwoods, to be the more important live tree used. Yeager (2005) found oak species to comprise 60 percent of the live trees used on the Hoopa Valley Indian Reservation, while conifers comprised approximately 84 percent of the live trees on the Shasta-Trinity National Forest. All three studies (Seglund 1995, Mazzoni 2002, Yeager 2005) found live conifer trees used as rest sites to average greater than 95 cm dbh. In general, fishers used cavities in snags and logs, nests (raptor and squirrel), witches brooms, and limb clusters in live trees. Yeager (2005), however, found a high level of cavity use in live black oaks.

Self and Kerns (1992) examined 34 rest sites used by three male fishers in northern California and found most (81 percent) of the rest structures were mistletoe clumps in live conifers averaging only 76 cm dbh. These results are consistent with Zielinski et al. (2004b) who also found, in the southern Sierra Nevada, an average size of 76 cm dbh for trees supporting mistletoe clumps or nests used as resting sites. Jones (1991) in Idaho and Weir and Harestad (2003) in British Columbia also found that fishers commonly use smaller trees for rest sites when sufficient witches brooms were present.

California fisher rest sites are generally found within forest stands with high canopy closures. Zielinski et al. (2004b) found southern Sierra rest site canopy closures to average 92 percent, and coastal northern California sites to average 95 percent. Truex et al. (1998) reported a mean rest site canopy

closure of 88 percent for fishers studied by Seglund (1995) and Dark (1997) in northern California, while Self and Kerns (1992) found a lower tree canopy closure (71 percent) at a managed forest in the Trinity Mountains (although Self and Kerns did note a moderate to heavy shrub coverage in their study area that was probably contributing to a higher overall canopy coverage).

Both Zielinski et al. (2004b) and Aubry and Raley (2006) found approximately 14 percent reuse of rest sites indicating fishers utilize, and may require, a large number of potential rest sites within their home ranges. In southern Oregon, Aubry and Raley (2006) located 641 different resting structures used by seven males and 12 females, or an average of nearly 34 structures per animal.

Fisher kits are born in natal dens and are then often moved to maternal dens as they grow larger (Lewis and Stinson 1998, Aubry and Raley 2006, Higley and Matthews 2006). Natal dens are typically found in tree cavities elevated well above the ground (Buck et al. 1983, Weir 1995, Zielinski et al. 1997a, Aubry et al. 1996), a specialized requirement that may have contributed to fishers' decline in the Pacific states due to the loss of these structures from timber harvest (Holthausen et al. 1994, Lewis and Stinson 1998). In California, Buck et al. (1983) reported a den height of 10.6 m from the ground, while Aubry and Raley (2006) reported an average cavity height of 16.2 m for 10 natal dens in southern Oregon. Five dens reported by Weir (1995) in British Columbia averaged 25.9 m. Abandoned pileated woodpecker nest cavities appear to be favored fisher natal dens, possibly because the cavity openings are large enough for females to enter, but small enough to bar entry by males (Aubry and Raley 2006).

All known fisher reproductive dens occurred in cavities in large live trees or snags; various tree species provide these dens. Maternal den trees are typically large and several may be used in a season to accommodate growing kits. Powell et al. (1997) found fishers to shift to larger trees with larger cavities as the breeding season progressed, which he attributed to the need for more space and ventilation for the developing young. In southern Oregon, Aubry and Raley (2006) too found maternal dens to occur in larger live trees and snags than those where natal dens occurred, and that while natal dens were all found in live or dead standing trees, maternal dens were often found in large hollow logs at ground level. Campbell et al. (2000) reported that there was little evidence of reuse, although Weir (1995) found it to occur in British Columbia.

Reported mean dbh of Oregon and California natal den live trees and snags ranged from 92 to 137 cm for conifers and 50 to 113 cm for hardwoods, while mean dbh for maternal dens ranged from 97 to 147 cm for conifers and 63 to 72 cm for hardwoods (Truex et al. 1998, Aubry and Raley 2006, Higley and Matthews 2006).

Fully functional ecological processes are necessary to create denning opportunities for fishers. Development of cavities occurs as a result of heart rot decay fungi that cause parts of the heartwood to collapse (Bull et al. 1997). This process occurs exclusively in live trees and it may take decades for cavities to develop (Manion 1991, Bull et al. 1997). It is conceivable that the large size of trees used for denning may be as much a result of the length of time it takes for these processes to create cavities as from the size of cavity required to accommodate a female fisher with kits. Tree cavities used by fishers may also result from broken branches, fire scars, physical damage, or pileated woodpeckers. Pileated woodpeckers excavate cavities sized for entry by female fishers in both live and dead trees; the presence of heartwood decay appears to be required for excavation in live trees (Bull et al. 1992, Aubry et al. 2000).

Territoriality and Home Range

Fishers exhibit intrasexual territoriality, where individuals defend a home range against members of the same sex, but there is considerable overlap between sexes (Johnson et al. 2000). These territories are

maintained year-round except during the breeding season when some males trespass into territories of other males while they search for receptive females (Powell 1993, Aubry et al. 2004).

The sexual dimorphism of fishers is also reflected in home range sizes. Powell (1993) summarized home range data from six fisher studies (California, Idaho, Maine, Michigan, New Hampshire, and Wisconsin) and calculated mean home range size estimates of 38 km^2 and 15 km^2 for males and females, respectively. Studies in California (Buck et al. 1983, Mullis 1985, Self and Kerns 1992, Seglund 1995, Dark 1997, Boroski et al. 2002, Mazzoni 2002, Zielinski et al. 2004a) also reflected this dimorphism with male home ranges ranging from 1.3 (Mazzoni 2002) to 5.7 (Zielinski et al. 2004a) and 6.3 (Mullis 1985) times greater than females. As these data show, male home ranges are typically larger than those of females, and probably reflect a differing pattern of resource use between the sexes (Lewis and Stinson 1998). Aubry et al. (2004) stated "large home ranges of males provide them with primary access to receptive females during the breeding season". Buck et al. (1994) speculated that females, with smaller home ranges, may be more susceptible to proportional changes in their home range habitat (due to fire or timber harvest) than males.

The largest California fisher home ranges, using the minimum convex polygon method, occur in northern California (mainly Shasta-Trinity National Forest). Here, Seglund (1995), Dark (1997), Zielinksi et al. (2004a), and Yeager (2005) recorded male home ranges averaging between 35.3 and 58.1 km^2, and females averaging between 12.9 and 26.1 km^2. In the Sierra Nevada, Mazzoni (2002) recorded average female home ranges of 11.9 km^2 and male home ranges of 21.9 km^2 in the Sierra National Forest, while Zielinski et al. (2004a) found females averaging much smaller home ranges (5.3 km^2) and males larger home ranges (30.0 km^2) in the Sequoia National Forest. Zielinski et al. (2004a) speculated that because black oaks provide favored resting and denning habitat, as well as important food for fisher prey, the higher presence of black oaks in his southern Sierra study site allowed for smaller home ranges. Hardwood forest types comprised 19 percent of the Zielinski et al.'s (2004a) southern Sierra study site compared to only nine percent for their northern California study site. Support for this speculation can be found by Yeager's (2005) recent studies on the Hoopa Valley Indian Reservation. Here hardwoods, mostly oak, comprised 70 percent of the live trees, with corresponding female and male average home ranges of only 1.7 and 7.4 km^2, respectively.

Movement and Dispersal

At about four months of age, juvenile fishers begin traveling within their mother's home range, and begin to disperse at about 10 months (Aubry and Raley 2006). Dispersal distances reported for fishers have varied in the literature. In a study in Maine, dispersal distances ranged from 4 to 23 km with males tending to disperse farther than females (Arthur et al. 1993). These short dispersal distances (relative to the size of an adult home range) were probably because the study population was trapped, leading to more vacant territories. In contrast, one male dispersed approximately 100 km in a population in Massachusetts (York 1996). Aubry et al. (2004) determined females in southern Oregon were more related to each other than were males, suggesting that females tend not to disperse as far from their natal areas as do males, which is a common relationship in mammals (Greenwood 1980). In support, juvenile males studied by Aubry et al. (2006) in southern Oregon dispersed nearly five times the average distance of juvenile females (29 vs 6 km). Dispersal information for populations of fishers in the Sierra Nevada is lacking.

Aubry and Raley (2006) reported on an adult male that for three successive breeding seasons traveled 30 km over the Cascade crest from its non-breeding season home range.

Food Habits

Because of a near universal preponderance of snowshoe hares (*Lepus americanus*) in the fisher diet, and the fisher's unique ability to kill porcupines (*Erethizon dorsatum*), it is often viewed as a predator specializing on these prey. Powell (1993), however, has shown fishers to be generalist predators, easily able to shift or adapt to other prey in the decline or absence of hares and porcupines. This is especially true in California where snowshoe hares are currently relatively rare (Williams 1986) and porcupine populations are greatly reduced. Snowshoe hares are considered to be globally secure according to the Natural Heritage System, while rating as vulnerable to imperiled in the state of California; considerable uncertainty exists. Porcupines are considered globally secure on the Natural Heritage scale, and secure to vulnerable in California. To date, neither species have been found to be more than trace components in the diets of fishers in California (Zielinski et al. 1999, Golightly et al. 2006), although Golightly et al. (2006) did find use of other rabbit species in northern California. Food habit studies by Grenfell and Fasenfest (1979) and Golightly et al. (2006) in northwestern California and Zielinski et al. (1999) in the southern Sierra Nevada show a wide diversity of prey. Common prey in all studies were squirrels (California ground squirrel [*Spermophilus beecheyi*], western gray squirrel [*Sciurus griseus*], and Douglas squirrel [*Tamiasciurus douglasii*]), mice (deer mouse [*Peromyscus* spp.], harvest mouse [*Reithrodontomys megalotis*], and voles [*Microtus* spp.]), deer (*Odocoileus* spp.) and elk (*Cervus elaphus*) carrion, beetles (Coleoptera), and social wasps. Golightly et al. (2006) also found relatively high use of chipmunks (*Eutamias* spp.), woodrats (*Neotoma* spp.), moles (*Scapanus* spp.), and shrew-moles (*Neurotrichus gibbsii*), while both Grenfell and Fasenfast (1979) and Zielinski et al. (1999) noted a high use of false truffles [*Rhizopogan* spp.]). Both Zielinski et al. (1999) and Golightly et al. (2006) found fishers also fed on lizards (*Elgaria* spp.) and berries (*Ribes* spp., *Arctostaphylos* spp.).

That California fishers easily respond to changing prey densities as found elsewhere (Kuehn 1989, Bowman et al. 2006) is reflected in the seasonal differences in diet. Increased use of mice and carrion in the winter and berries in the fall probably mitigate for the lack of availability of hibernating squirrels and reptiles (Zielinski et al. 1999), and reflect an opportunistic strategy. Further, the diversity of prey in the diet of southern Sierra fishers may also reflect the diversity of habitats (and niches) in this region. Many of the prey species found in the diet of fishers occur primarily in large tree and dense canopy coniferous forests and oak woodland habitats, while others prefer chaparral and deciduous riparian areas (Zielinski et al. 1999). Oak, especially, may be important as sources of mast that may stimulate higher prey densities (Yeager 2005). In general, as compared to more northern areas in the west where fishers occur, the drier southern Sierra Nevada provides a diversity of habitats and prey species, following a recognized pattern of increased species richness with decreased latitude (Pianka 1966). This pattern may also manifest in the diverse diet of the southern Sierra population of fishers, especially with the emergence of reptiles, insects, false truffles, and berries as important food items.

Community Interactions

Buskirk (1999) described ways mesocarnivores interact within an ecological community. They include influencing the behavior and demography of prey (Johnson and Sargeant 1977, Krebs et al. 1995), recycling of nutrients by scavenging carrion (Hornocker and Hash 1981, Martin 1994), influencing plant and fungus distribution patterns by dispersing propugules (Willson 1992), influencing the distribution and abundance of competitors, and vectoring diseases and parasites.

Cook and Hamilton (1957) suggested that fishers could biologically control high porcupine densities because fishers have a unique ability to dispatch porcupines, they prey on porcupines where the species co-occur, and because porcupine populations have been noted to increase as fisher populations

decrease (Stone 1952) or vice versa (Powell and Brander 1977, Earle 1978). In fact, fisher reintroductions in the West during the 1950s and 1960s were based on this premise. Further, the widespread eradication of porcupines in the Sierra Nevada by aerial application of poison bait has been suggested as a possible explanation for the extirpation of fishers in the northern and central Sierra Nevada, although direct mortality of fishers from the strychnine bait is also plausible (Barrett 1997). (Former staff with the Tahoe National Forest have reported that during the 1970s they were involved in the broad application of strychnine baits to control porcupines in the "checkerboard" area of the central Sierra Nevada.) Nevertheless, some populations of fishers survive in the absence of porcupines, and fisher reintroductions into areas of high porcupine density have failed (Aubry and Lewis 2003). The diet studies by Grenfell and Fasenfast (1979), Zielinski et al. (1999), and Golightly et al. (2006) did not find any evidence of porcupines in the diet of fishers from northwestern California or the southern Sierra Nevada.

Universally more important fisher prey than porcupines are snowshoe hares (Powell and Zielinski 1994). In fact, energetically, snowshoe hares are probably the most important prey, especially across Canada where fisher populations will cycle (with a 3-year lag) with that of the hare (Bulmer 1974, 1975). California, however, is an exception in regard to snowshoe hares as well. Both diet studies from California (Grenfell and Fasenfast 1979, Zielinski et al. 1999) failed to detect hares in the diet of their respective fisher populations. However, both studies occurred in regions of California (northwest coastal and southern Sierra) where fishers and snowshoe hares may not be coincident.

Carrion, especially deer carrion, is universally important in the winter diet of fishers (Powell and Zielinski 1994). This apparently holds true for fisher populations in California. Although their sample size was small (n = 8), Grenfell and Fasenfast (1979) found deer carrion in 25 percent of the gastrointestinal (GI) tracts sampled. The presence of deer, moose, elk, caribou, and even cattle in the diet of fishers clearly indicates fishers will consume carrion when available and, therefore, are an important contributor to recycling these nutrients.

Both soft (apples, berries, and cherries) and hard (nuts and acorns) mast are frequently found in the diet of fishers (Powell and Zielinski 1994), and may represent an important supplemental food source. For those fruits with seeds that can survive digestive processes, fishers can provide a means for dispersing these plants across the landscape. This can also be true for various species of fungi, especially in California. All eight fisher gastrointestinal tracts (GI) from northwestern California examined by Grenfell and Fasenfast (1979) contained considerable quantities of false truffle (*Rhyzopogon* spp.), while Zielinski et al. (1999) found fungal spores or tissues in 17 of 24 fisher scats from the southern Sierra Nevada. Although some of the fungal spores found in fisher GI tracts may have originated in the GI tracts of mycophagous small mammal prey, such as northern flying squirrels or western red-backed voles, the volume of fungal material suggests fishers are foraging directly on fungi (Zielinski et al. 1999). Regardless of the mode of ingestion, fishers contribute to the long-distance dispersal of hypogeous fungi spores (Aubry et al. 2002).

Because fishers and American martens are both arboreal mesocarnivores that occupy coniferous forests and prey on small mammals, there is the potential for competition where the two species occur in sympatry. However, in the West fishers and martens tend to separate spatially with the latter occupying the higher snow-laden elevations (Buskirk and Ruggerio 1994; Krohn et al. 1995, 1997). Martens are better adapted to traveling and hunting in deep, fluffy snow than fishers (Raine 1983; Arthur et al. 1989b; Krohn et al. 1995, 1997). In the southern Sierra sympatric fishers and martens co-exist probably by partitioning their foraging niches, although Zielinski and Duncan (2004) found a high dietary overlap between the species that may be unique to this extreme southern end of both species' ranges.

Lynx (*Lynx canadensis*) have not historically occupied the Sierra Nevada, but bobcats (*Lynx rufus*) are found there and may compete with fishers for certain prey (Powell and Zielinski 1994). Recent results from Golightly et al. (2006) found gray fox (*Urocyon cinereoargenteus*), skunk (Mephitinae), and raccoon (*Procyon lotor*) remains in northern California fisher diets, which they attributed to predation (rather than scavenging) suggesting fishers view these mesocarnivores as prey. Finally, wolverines (*Gulo gulo*), a high-elevation species, may, in addition to snow depth, have played a role in limiting fisher populations to mid-elevation forests (K. Aubry, pers. comm.).

Although fishers, like all mesocarnivores, are subject to various diseases and parasites, these pathogens are not known to affect them at the population scale, probably because of a weak transmission pathway due to fishers' solitary nature (Coulter 1966, Powell 1977) and tendency to avoid proximity to other individuals (Powell 1977, Arthur et al. 1989a). However, in 53 California fishers recently tested on the Hoopa Valley Reservation (Brown et al. 2006), researchers have found the presence of potentially lethal West Nile virus, canine distemper virus, canine adenovirus, canine herpes virus, and a feline-parvovirus-like virus, as well as an 83 percent exposure to *Anaplasma phagocytophilum*, a tick-borne infectious agent for granulocytic anaplasmosis, suggesting disease may play a larger role than originally thought. However, it also should be noted that fisher densities are among the highest found anywhere, which might account for the prevalence of diseases found there. The inter-relationship of fishers and parasites at the forest ecosystem level is little understood (Aubry et al. 2002).

Fishers also appear to have an important commensal relationship with pileated woodpeckers. By using abandoned pileated woodpecker nests for natal denning, these woodpeckers contribute to fisher survival. The entrances of pileated cavities are large enough for entry by females, but too small for males, which may prevent males from entering these den cavities and killing kits (Aubry and Raley 2006).

CONSERVATION STATUS

Extant fisher populations in the Pacific states appear limited to northwestern California, the southern Sierra Nevada, and two small populations in southern Oregon (one a reintroduced population and the other a native population possibly linked to California) (Zielinski et al. 1997b, Aubry and Lewis 2003). They are believed to be extirpated from Washington State (Lewis and Stinson 1998), where they were the subject of an assessment evaluating the feasibility of reintroduction (Lewis and Hayes 2004). Commercial trapping and the loss of late successional forest habitat have been implicated as the chief reasons for the decline of fisher populations throughout its range (Powell and Zielinski 1994). However, while many eastern populations have recovered, those in the western United States have not, especially in California's north and central Sierra Nevada, in spite of the prohibition of trapping since 1946 (Lewis and Zielinski 1996). Zielinski and Mori (2001) have stated that the failure of Sierra Nevada fishers to reoccupy suitable habitat indicates that either "(1) insufficient habitat exists for dispersing animals to found new populations, (2) existing populations are too small to provide sufficient numbers of dispersing animals to recolonize the vacant areas, or (3) dispersal habitat is of poor quality, or is interrupted by non-forest land uses and roads, and dispersing animals succumb or are killed during dispersal." It is also possible that natural barriers, such as large rivers, may impede dispersal (Coulter 1966, Powell 1993). The Kings River in the southern Sierra Nevada may be such a barrier (Wisely et al. 2004), although Aubry and Raley (2006) found breeding male fishers in southern Oregon to regularly cross the Rogue River.

It appears apparent that there has been essentially a complete extirpation of fishers in the northern and central Sierra Nevada. Suggested factors responsible for this loss include legal harvest prior to 1946 coupled with illegal or incidental harvest during the ensuing years (Lewis and Zielinski 1996), secondary poisoning and/or prey loss during the intensive predator and rodent control (especially porcupine and pocket gopher control) programs since 1915 (Wild and Roessler 2004), and habitat loss from timber harvest or forest fires (Wild and Roessler 2004). Regardless of which factor or combination of factors is responsible, recovery of fishers in these areas may require human intervention (translocation from extant populations), especially if fisher dispersal behavior, coupled with manmade and natural barriers, prevents natural dispersal into the unoccupied areas.

The extant populations of fishers in the Sierra Nevada have been the subject of legal debate since they were first petitioned for listing under the Endangered Species Act in 1990, and then again in 1994. Both petitions were denied by the U.S. Fish and Wildlife Service citing that there was "insufficient scientific information" to recommend listing (U.S. Fish and Wildlife Service 1996). Central to this decision was a lack of genetic information needed to confirm that the West Coast (Washington, Oregon, and California) populations of fishers constituted a "distinct population segment." The U.S. Fish and Wildlife Service was again petitioned in 2000 (Center for Biological Diversity et al. 2000) supported by new genetic and distribution information. After a 2003 court order, the U.S. Fish and Wildlife Service completed a 12-month review of the petition (Wild and Roessler 2004) and concluded that listing of this species is "warranted but precluded by other, higher priority listing actions." This ruling does require annual review by the U.S. Fish and Wildlife Service until a listing proposal is published, or subsequent information establishes that listing is no longer warranted. The species has since been added to the U.S. Fish and Wildlife Service's candidate species list, and a proposed rule for listing pursuant to the Listing Priority System is under development.

In California, the Forest Service has listed fishers as a Regional Forester's Sensitive Species (Macfarlane 1994), obliging the agency to manage habitat in a manner that does not contribute to a need to list this species as federally threatened or endangered under the Endangered Species Act of 1976.

Habitat for Sensitive Species must be managed to ensure maintenance of viable, well-distributed populations arrayed across the landscape to allow for reasonable access to mates, as well as to minimize impacts on fishers in individual forest plans (165 U.S.C. 1604). The Sensitive Species policy of the National Forest System is designed to meet the National Forest Management Act of 1976 (NFMA) regulations (36 CFR 219.19) requiring maintenance of biological diversity in a planning area (like that covered by individual forest land and resource management plans). The State of California classifies fishers as a "species of concern" and a protected furbearer.

RISK FACTORS

Introduction

Risk factors can be described as those stressors that have led to fisher decline in the Sierra Nevada Planning Area, especially those that may still be operating. They also include new factors that have arisen or increased since population decline that may limit or imperil future conservation efforts to recover these populations. Risk factors may impinge upon individuals, populations, habitat, or prey, and can include both anthropogenic and natural forces.

Factors Affecting Habitat

Conserving fishers in the Sierra Nevada Planning Area will require the retention or restoration of sufficient habitat and habitat connectivity throughout the bioregion. Bioregional scale processes and patterns such as metapopulation dynamics, land use, and vegetation may be important determinants of fisher distribution. Given the apparent reluctance of fishers to cross open areas (Coulter 1966, Raine 1981, Weir and Harestad 2003), and the limited mobility of terrestrial mammals relative to birds, it is more difficult for fishers to locate and occupy distant, but suitable, habitat. Fishers prefer continuous or nearly continuous forests, and extensive logging has been identified as a major contributing factor in fisher declines in the Pacific Northwest (Powell 1993). The loss of structurally complex forest habitat (SNEP 1996) and the fragmentation of suitable habitat by roads and residential development (creating dispersal barriers or mortality sinks) may have contributed to both the loss of fishers from the central and northern Sierra Nevada and their failure to recolonize these areas. Recent genetic work by Wisely et al. (2004) on extant California populations found limited gene flow supporting the notion of low dispersal ability and susceptibility of these remaining populations to extinction.

Fishers have low reproductive rates, large home ranges (for carnivores of their size), apparent limited dispersal (Wisely et al. 2004), and exist in low densities throughout their range in western North America (with the possible exception of the Hoopa Valley Indian Reservation in California [Yeager 2005]). In combination, these characteristics suggest that fishers are prone to localized extirpation, their colonizing ability is limited, and populations would be slow to recover from deleterious impacts. Isolated populations, therefore, may have a lower likelihood of persisting. Because habitat connectivity is a key to maintaining fishers within a landscape, activities that result in a loss of functional connectivity may have a negative impact on fisher distribution and abundance.

There are contrasting views on the importance of late-successional forest to fishers, at least at the home range level. Some studies have shown a strong association of fishers with late-successional forests (e.g., Buck 1982, Jones and Garton 1994), while others indicate fishers are more closely associated with mid-seral forests (e.g., Arthur et al. 1989b, Self and Kerns 1992, Zielinski et al. 2004a). Perhaps the most universal agreement is that fishers use conifer forests with dense canopies (from a fisher's perspective),

and for rest and den sites, they select structural components (e.g., large trees, snags, and downed logs) most often found in late-successional forests. Zielinski et al. (2004a) found that while fishers home ranges in the southern Sierra Nevada were dominated by Sierran mixed conifer and ponderosa pine stands in 29 to 61 cm dbh size class, 66 percent of the habitat had a canopy closure greater than 60 percent. Carroll et al. (1999) found that in northwestern California, fishers were strongly associated with high canopy coverage at both the home range and landscape level. In contrast, Self and Kerns (1992) found fishers using stands of relatively low tree canopy coverage, but their study site had a significant shrub component that may have contributed to the overall canopy coverage.

Fishers need sites for resting and denning secure from predation and weather (Aubry and Raley 2006). Cavities, raptor nests, mistletoe clumps, and branch platforms are more commonly found in the larger size classes of trees, snags, and downed logs. In California, the average dbh for live conifers used for rest sites varied between 95 and 125 cm, and for snags between 118 and 120 cm (Seglund 1995, Mazzoni 2002, Zielinski et al. 2004b, Yeager 2005), with the exception of male fishers on industrial forest lands that used smaller live conifers (76 cm dbh) with a high prevalence of mistletoe brooms (Self and Kerns 1992).

Habitat elements important to fishers at the landscape, home range, and rest/den site level include:

1. Dense over-fisher canopy cover (Buck et al. 1994, Buskirk and Powell 1994, Dark 1997, Carroll et al. 1999, Zielinski et al. 2004a, Zielinski et al. 2004b, Yeager 2005),
2. Presence of large-diameter snags (Allen 1987, Powell and Zielinski 1994, Mazzoni 2002, Aubry and Raley 2006, Higley and Matthews 2006) distributed across the landscape,
3. Large downed logs (Buskirk and Powell 1994, Self and Kerns 2001, Slauson et al. 2003, Aubry and Raley 2006) distributed across the landscape, which seem to play a larger role from northwestern California northward,
4. Large-diameter greater than 61 cm (or 24 in) dbh live conifer and hardwood trees with decadence such as broken tops or cavities (Zielinski et al. 2004a,b; Yeager 2005; Aubry and Raley 2006; Higley and Matthews 2006),
5. Complex structure near the ground (e.g., downed logs, large downed branches, root masses, live branches, and other coarse woody debris) (Buskirk and Powell 1994, Weir and Harestad 2003),
6. Multi-layered vegetation (vertical within-stand diversity) (Banci 1989),
7. Low road density (Dark 1997),
8. Mistletoe platforms (Arthur et al. 1989b, Jones, 1991, Self and Kerns 2001, Weir and Harestad 2003), and
9. Connectivity between suitable habitat patches (Coulter 1966, Earle 1978).

Reduction of any of these elements could pose a risk to fishers. The exact amount and extent of reduction that might result in loss of habitat suitability for fishers at the various scales has yet to be determined. It seems reasonable to assume that reduction in multiple habitat elements may create a negatively synergistic effect on habitat quality. In addition, selection of natal (birthing) and maternal (kit-raising) dens is highly specific. Habitat components may need to exist in certain juxtapositions within specific habitats in order to provide a secure environment for birth and rearing of fisher kits. Known natal and maternal dens in the western United States have been in large-diameter, downed logs, large snags, or cavities in large-diameter live conifers or hardwoods (Powell and Zielinski 1994, Zielinski et al. 1997a, Truex et al. 1998, Aubry and Raley 2006, Higley and Matthew 2006). Most (68 percent) of the 47

natal and maternal dens found by Higley and Matthews (2006) in northwestern California were located in live oak (tanoak and black oak) trees, followed in importance by Douglas-fir snags. In southern Oregon, Aubry and Raley (2006) found live conifers, followed by conifer snags, and conifer logs as the structures most used by denning fishers, with Douglas-fir the most important tree species of 31 dens sampled. All 13 natal dens were in found in tree cavities, while 5 of the 18 maternal dens were found in downed logs.

Other risk factors affecting habitat for this species include rural or recreational development that fragments habitat, creates dispersal barriers, or creates ecological sinks where mortality exceeds reproductive output. Disease and climate change are also risk factors for fishers. Although diseases affect individuals, there may be a habitat factor as well related to development. Studies on urban-wildland interfaces suggest a correlation between the prevalence of disease in wild populations and contact with domestic animals (Riley et al. 2004). As evidence, Brown et al. (2006) found fishers in northwestern California to be exposed to canine forms of distemper, herpes, parvovirus, and adenovirus, although linking domestic dogs as a viral source is only speculation at this time. Climate change may have a profound effect on fishers, both positive and negative, especially for populations surviving at the periphery of the species' range.

Arguably, the greatest threat to fishers in the Sierra Nevada is loss of habitat due to uncharacteristically severe wildfire. After a century of fire suppression, the relatively dry forest types are experiencing a fuels build-up that once ignited, results in severe, often stand-replacing fire over large areas of the landscape. With the exception of canopy cover, fisher habitat elements such as large diameter live and dead trees take 50 to 100 or more years to regenerate. Loss of those elements to wildfire removes suitable habitat for many generations of fishers. To restore the ecological balance, prevent such large-scale loss of habitat and timber, and ameliorate threats to human health and safety, forest managers have embarked on an expensive program of fuels reduction in the Sierra Nevada.

Fuels reduction may take one of two primary forms, and often involves use of both. Mechanical vegetation treatments may be implemented to remove ground-based and "ladder fuels" (vegetation at intermediate heights in the canopy that could carry a ground-based fire into the tree canopy where it may burn much hotter and spread much faster). The general tools and processes available to forest managers to conduct such fuels reductions are discussed in the following sections of this document. Another fuels reduction tool is prescription burning, where a fire is intentionally ignited in the understory for the purpose of burning off the excess fuels. This is often used in combination with mechanical treatments as a secondary treatment.

What is generally perceived as the next greatest threat to Sierra Nevada fishers is the removal of key structural elements of the habitat, which can at times result from mechanical vegetation treatments designed to reduce fuels loading. Loss of large trees and snags with lateral limbs, mistletoe brooms and other indicators of decadence can reduce the amount of habitat suitable for fisher denning or resting. Since canopy cover regenerates fairly quickly, temporary reductions may pose less of a threat to fishers than loss of structural elements.

Fragmentation and isolation of extant fisher populations and/or suitable habitat is documented at multiple spatial scales on the West Coast (Zielinski et al. 1997b, Zielinski and Mori 2001, Aubry and Lewis 2003, Campbell 2004, Wild and Roessler 2004, Wisely et al. 2004). The extent of this threat can only be calibrated by an analysis of the ability of fishers to recolonize alienated habitat.

Risk factors specifically affecting habitat or habitat connectivity follow.

Forest Management

This section describes potential risks to fishers from forest management activities, including even-aged management, group selection, thinning, salvage harvesting, hazard tree removal, fuelwood collection, and establishment and maintenance of defensible fuels profile zones.

Management activities that remove overhead cover, large-diameter trees, or coarse woody debris are risk factors for fishers where they affect their foraging, resting, and denning habitat (Wild and Roessler 2004). Past logging activities have been implicated as a contributing factor in the observed declines in the western states' populations (Lewis and Stinson 1998), especially where they have removed the above-noted habitat features (e.g., large trees, snags, and logs) across much of the fisher's range (Rosenberg and Raphael 1986, Lyon et al. 1994, Powell and Zielinski 1994). The history of timber harvest in the Sierra Nevada has resulted in many forested areas that lack large tree and snag components that were once present on the landscape (Franklin and Fites-Kaufman 1996, Bouldin 1999). Although fishers appear in some cases to tolerate timber harvest activities where residual habitat features remain (Self and Kerns 1992), management activities that significantly reduce canopy coverage or late-successional forest features should be considered viable risks to extant fisher populations, and to the recovery of future populations.

Even-Aged Management (Clear-cutting)

In general, under an even-aged management system all trees within a 5-to-30 acre harvest unit are removed, and the stand regenerated, often with nursery stock (Smith 1962). Site preparation to remove slash and competing shrubs and trees is conducted through mechanical methods, burning, or herbicides. Thinning to remove young overstocked trees is often an interim step before harvest of the stand again at the end of the stand rotation.

Today, even-aged management is rarely used on public lands in the Sierra Nevada, except where needed to regenerate ecologically valued conditions (e.g., giant sequoia [*Sequoiadendron giganteum*] or aspen [*Populus tremuloides*] stands). However, much of the privately owned lands of the Sierra Nevada and Modoc Plateau (36 percent of the land base) are managed using the even-aged silvicultural system, especially in forests used for industrial timber. Three industrial timber companies (Sierra Pacific Industries, Collins Pine Company, and lands formerly belonging to Georgia Pacific-which has now left the state) manage nearly 200,000 ha (500,000 acres [ac]) of land under the even-aged system.

Because even-aged management involves a complete removal of forest structure, at least at the stand level, it can have significant localized impacts on fisher populations and their habitat. However, given the current limited usage of even-aged management, any impacts to fishers on Sierra Nevada public lands, including Forest Service lands, are likely residual. On industrial forest lands in the Sierra Nevada, however, even-aged management practices continue, which may limit successful reintroduction of fishers into these areas. Studies are currently underway in northern California (Green Diamond Resource Company, Sierra Pacific Industries) to better understand the impacts of industrial forest practices on fisher populations in this region, and to better elucidate how fishers use these industrial forests where they are coincident.

Group Selection

Group selection is an uneven-aged management system that harvests trees and establishes new age classes in small groups (Helms 1998). The openings created in the stands allow enough sunlight and soil moisture to promote regeneration, survival, and growth of tree seedlings (Burns 1983). The width of these small groups is commonly approximately twice the height of mature trees (Helms 1998), generally

less than one ha (2.4 ac). The size of the openings may be adjusted to meet the photometric requirements for species to regenerate.

The group selection system differs from clearcutting in that the intent is ultimately to create a balance of age or size classes in an intimate mixture or in a mosaic of small contiguous groups throughout the forest (Burns 1983), although the largest group selection units can resemble small clearcuts. With group selection, groups are not managed separately after they are initially formed. Regeneration, growth, and yield are managed over the entire stand. Implementation of group selection harvests may be used to reduce disease centers of infected trees (e.g., dwarf mistletoe [*Arceuthobium* spp.]) or promote diversity in stand age and structure. Decisions of how and when to implement group selection are based on 1) current age structure of the land base, 2) pathogen conditions and risks, 3) age structure of individual stands, and 4) economic considerations. Under economic objectives, groups might be formed within approximately 10 percent of the stand once every 10 years, with the rest of the stand being thinned. A 20-year interval is probable under a multiple-use objective, with a complete rotation occurring in 200 years. The Forest Service does not expect to fully manage and regulate any area of NFS lands via group selection (M. Landram, pers. comm.).

The practice of group selection on NFS lands in the Sierra Nevada mountains has been limited to two areas, the Sierra National Forest since about 1995, and the Herger-Feinstein Quincy Library Group Act (HFQLG) area since 2000. The HFQLG area is composed of the Lassen and Plumas National Forests and the Sierraville Ranger District of the Tahoe National Forest. In these limited areas, the footprint of groups created relative to the total forested area is very small when considered at the landscape scale. (M. Landram, pers. comm.). Effects to those areas as a result of group selection vegetation manipulation are best analyzed at the fisher home range or daily movement scale.

In general, group selection is applicable to most of the forest types across the elevation ranges where fishers are found or have been found on Forest Service lands. The exception is under certain conditions within ponderosa pine forests (M. Smith, pers. comm.). Because of the ponderosa pine's requirement for light, group selection is less applicable in ponderosa pine stands where conditions restrict sunlight. Therefore, the technique is less applicable in the northern Sierra and on steep slopes where forests are naturally more even-aged. Regeneration is good within small groups formed using this technique in the southern Sierra.

Little is known about the impacts of uneven-aged management practices on fishers, especially in California. Many investigators have documented selection by fishers for closed-forest types (Buskirk and Powell 1994, Jones and Garton 1994) and avoidance of open canopy areas (Arthur et al. 1989a; Buck et al. 1983, 1994; Coulter 1966; Jones 1991; Jones and Garton 1994; Kelly 1977; Powell 1977; Roy 1991). Fishers have, however, been observed to use recently clearcut areas with little overhead tree cover in northern California (R. Golightly, pers. comm.; J. Yaeger, pers. comm.) and areas with some low overhead cover from shrubs and saplings (B. Boroski, pers. comm., Kelly 1977 for eastern fishers).

Powell and Zielinski (1994) proposed that small patch cuts, group selection harvests, and small clearcuts could superficially mimic wind-throw and fire, and benefit fishers because they evolved in forests where wind-throw and fire were common. Group selection harvests could potentially increase stand-level habitat quality where adequate forest structures are otherwise available. Studies of radio-collared fishers in Idaho (Jones and Garton 1994) and Maine (Arthur et al. 1989b) indicated that harvesting individual trees or small plots (less than five ha) may have little negative impact because such openings may increase within-stand diversity and prey diversity.

However, Powell and Zielinski (1994) have also suggested that fishers presumably experience habitat loss when timber harvest removes overstory canopy created by large trees from areas larger and more extensive than would naturally wind-throw and succumb to fire. The juxtaposition of large clearcuts and numerous, adjacent, small clearcuts of similar age could create conditions unfavorable for use by fishers. Thinning between groups within a stand also has the potential to reduce the multi-layered structure of stands beyond the effects of group selection. With thoughtful design, however, group selection could be used to enhance horizontal diversity and increase the abundance and diversity of prey species.

Short-term direct effects may include temporary disturbance to individual fishers resting or denning near harvest activities, and localized reduction of foraging, resting, and denning habitat. Group selection harvest often targets dwarf mistletoe infections, yet mistletoe brooms are important rest site components for California fishers (Self and Kerns 1992, Mazzoni 2002, Zielinski et al. 2004b). Indirect impacts to denning habitat could potentially occur regardless of season. Previous evidence indicates that fishers exhibit the greatest selection for resting and den sites, suggesting that these structures may be the most limiting habitat element (Arthur et al. 1989b, Powell and Zielinski 1994). The removal of potential den trees could have a localized impact on the fisher populations, especially if the harvest occurs during the reproductive period.

Proper juxtaposition of group selection harvests, and identification of where adequate forest structures are otherwise available, could potentially increase stand-level habitat quality while maintaining habitat connectivity within a landscape. If group selection activities are not adequately coordinated across the forest as a whole, their cumulative impact could create unsuitable conditions.

In conclusion, careful planning and use of group selection harvest techniques have the potential to promote fisher habitat by perpetuating a diverse uneven-aged forest. Although the effects of uneven-aged timber management practices on fishers are not well understood, group selection is compatible with the objectives of promoting diversity in stand age and structure, which in turn could benefit fishers. In contrast, increasing the frequency of harvests, harvesting too much of the stand, establishing the groups too close together, or overuse and poor coordination across the landscape may adversely affect fishers. On federal lands, however, the current management direction stated in the SNFPA Final Environmental Impact Statement (FEIS) (USDA Forest Service 2001, USDA Forest Service 2004) uses a landscape-scale strategy of land allocations, combined with stand-level management standards and guidelines, to conserve old forest ecosystems and their associated wildlife species such as fishers.

Thinning

The term “thinning” applies to cuttings made in immature stands to stimulate growth of remaining trees to increase the total yield of useful material (Smith 1962). Thinning may be conducted to achieve a variety of objectives including improvement of habitat for fishers. As currently applied in the Sierra Nevada, thinning is a practice specifically designed to increase resistance to wildfire and insect attack (M. Landram, pers. comm.). It may be used to improve forest health, reduce fuels loading and decrease plantation density. Surplus trees are removed with the objective of reducing competition by regulating the distribution of growing space for the advantage of the existing crop (Smith 1962). Thinning has been shown to maintain stand vigor and stability, produce large trees, and initiate the development of understory trees (Thomas et. al 1990). Thinning may, however, have a considerable and rather complex effect upon the forest soil and its productivity as it lessens the annual crop of litter, lets in sun and wind, which dry surface layers, and may change the flora of the forest floor, favoring the invasion of more xerophytic plant species (Baker 1934). Slash produced by thinning may be treated using prescribed fire,

which in itself can have a profound effect on the stand and its ability to support fishers (see Prescribed Fire).

In the 1960s, the Forest Service and private timber companies started applying even-aged management throughout the Sierra Nevada. The legacy from this past approach is four to eight ha (10- to 20-ac) even-aged stands, overstocked with young-aged trees, across the length of the west slope of the Sierra Nevada. Consequently, thinning is today a common silvicultural practice to reduce competition and increase tree vigor in these stands.

The objectives for each stand determine the degree to which the stand is thinned. Under economic objectives, thinning may be heavier and can occur every 10 years or so until the stand grows back to full stocking (crowns closed, growing capacity fully utilized, includes grass and shrubs). If multiple-use is the objective, a 20-year span between entries may be more appropriate. Full harvest rotation may occur in red fir (*Abies magnifica*) and white fir (*A. concolor*) forests on average between 70 and 125 years, while Sierra Nevada mixed conifer types on average have a rotation of 85 to 130 years (Burns 1983). Although thinning is usually applied to a stand to increase growth rate, size, and usefulness of the trees for wood productions, it can also be used to speed the development of individual stands for other reasons, such as wildlife habitat enhancement.

The effects of thinning on fisher habitat depend on the amount and juxtaposition of remaining suitable habitat and the amount of redevelopment time since harvest of adjacent areas. Fishers typically avoid areas with low canopy cover, large forest openings, clearcuts, and other cleared areas (Buck et al. 1983, Arthur et al. 1989a, Arthur et al. 1989b, Powell 1993, Buskirk and Powell 1994, Jones and Garton 1994, Weir 1995). Thinning temporarily reduces overhead canopy cover to a level that may or may not be below that used by fishers, and the effects may be temporary.

Thinning generally occurs in young stands that are not considered to be optimal or preferred fisher habitat because they generally lack mature structure. Early successional even-aged forests likely do not provide the same prey resources, rest sites, and den sites as more mature forests (Powell and Zielinski 1994). However, young forests may be suitable for seasonal foraging or travel if appropriate overhead cover is available. Buck (1982) and Mullis (1985) documented fishers hunting in plantations with greater than 80 percent canopy cover and average tree heights of 1.5 to 3.0 m. Jones and Garton (1994) observed that within young forest stands used in winter, Idaho fishers selected sites with high availability of large trees (≥ 47 cm dbh), snags (≥ 52 cm dbh), and logs (≥ 47 cm diameter). When using young forest stands, fishers often sought areas with at least one large tree, snag, or log that had survived stand-replacing fires (Jones and Garton 1994). Jones (1991) concluded that fishers in Idaho may not be old-growth-dependent and that viable populations can be maintained as long as adequate proportions or components of mature forest are available.

Short-term direct effects of thinning may include temporary disturbance to individual fishers resting or denning near harvest activities, direct take of individuals resting or denning in felled trees, and the localized reduction of foraging, resting, and denning habitat. Previous evidence indicates that fishers exhibit the greatest selection for resting and den sites, suggesting that these structures may be the most limiting habitat element (Arthur et al. 1989b, Powell 1994b, Powell and Zielinski 1994). The removal of potential den site trees could have a localized impact on fisher populations, especially if the harvest occurs during the reproductive period. However, thinning generally occurs in young stands where denning and resting structures have not yet developed.

Well-designed silvicultural activities in the young regenerated stands have the potential to accelerate the development of structural attributes associated with mature forests. Thinning may reduce

the risk of stand-replacing events and could, if implemented properly, lead in the long term to larger tree sizes. The results of thinning are also more predictable than prescribed fire, especially with regard to maintaining legacy elements such as large trees and snags.

Hardwood Management

Hardwood forests comprise 11.3 million acres, or 40 percent of all California forest lands (Waddell and Barrett 2005). Yet hardwoods, primarily oaks (blue oak [*Q. douglasii*], canyon live oak [*Q. chrysolepis*], California black oak, tanoak [*Lithocarpus densiflorus*], interior live oak [*Q. wislizeni*], coast live oak [*Q. agrifolia*], and Oregon white oak [*Q. garryana*]), represent less than one percent of the timber harvested in California (Morgan et al. 2004). The 2000 hardwood timber harvest in California was about 10.7 million board feet, which represents 0.1 percent of the standing volume of hardwoods on unreserved lands. In the Sierra Nevada Planning Area, commercial hardwood timber harvest occurs almost exclusively on the Plumas (426,000 board feet in 2005, or less than one percent of the total Plumas timber harvest) and Lassen (3,000 board feet in 2005) National Forests (2005 R-5 Cut & Sold Report). Hardwood use on other Sierra Nevada forests is primarily limited to fuelwood harvest (see Fuelwood Collection).

Oak is an important habitat component for California fishers (Self and Kerns 1992, Klug 1997, Higley et al. 1998, Yeager 2005), including extant southern Sierra populations (Truex et al. 1998, Zielinski et al. 2004a). Oaks, especially California black oak, provide not only denning and resting structures for fishers (Zielinski et al. 2004b, Yeager 2005), but oak mast provides food for important fisher prey (Yeager 2005). Obviously, harvest practices that significantly reduce oak structure within fishers' forest environment have the potential to affect fisher habitat and populations adversely. However, the current hardwood harvest locations and levels suggest that hardwood management poses little threat to fisher conservation and recovery. Future utilization of hardwoods in the Sierra Nevada should, however, thoroughly evaluate the potential risks to fisher recovery.

Salvage Harvest

Salvage is the harvesting of dead, dying, or deteriorating trees from an area following a fire, wind, insect infestations, or disease before their timber becomes economically worthless. The primary purpose of salvage cutting is to remove merchantable trees that have been or are in immediate danger of being killed or damaged by injurious agents other than competition between trees (Smith 1962). Because the objective is to use the injured trees with minimal financial loss, salvage harvests are generally not conducted unless the trees removed will at least pay for the expense of the operation (Smith 1962). Pre-salvage cutting occurs in anticipation of damage by removing highly vulnerable trees.

Salvage removal of dead and dying trees plays an important role in reducing future fire hazard, decreasing public safety concerns, preparing areas for planting following a stand-replacing catastrophic event (M. Landram, pers. comm.). Salvage harvest is practiced throughout the historical range of fishers in California. The pattern of removal depends upon the stand-replacing event that caused the death or deterioration of the trees. When salvage harvest occurs over a large area, it contributes to even-aged stand regeneration created by the original catastrophic event.

Drought can cause the die-off of individual sugar pines in the southern Sierra. Salvage harvests removing individual trees perpetuate an uneven-aged forest. Salvage harvest is typically conducted in areas where the practice is economically feasible. That is, where the value of the timber removed exceeds the cost of operations to remove it. Trees are removed in areas where an existing roadway leads to the salvage area and the dead trees can be cabled out. Helicopters may be used if the tree's value warrants the expense. However, if the wood has become economically worthless, trees and snags will be felled and left on site provided there is a hazard proposed by allowing them to remain standing. Larger salvage

harvests may be planted and treated with herbicides and rodenticides to promote regeneration. These post-harvest treatments expose fishers to additional effects that may have adverse consequences. Depending on the size of the salvaged area, cutting may take more than one season (late August-early November). The frequency with which salvage harvests occur depends on fire frequency, disease outbreak, and drought.

Fishers exhibit the greatest selection for resting and den sites, suggesting that these structures may be the most limiting habitat element (Arthur et al. 1989b, Powell 1994b, Powell and Zielinski 1994). Fishers' daily resting locations are diverse in tree species and structure. Live trees with broken tops, cavities, witches brooms, or squirrel nests; snags; logs; stumps; and brush piles have been described as resting sites during various seasons (Arthur et al. 1989b, Powell 1993, Kilpatrick and Rego 1994, Seglund 1995, Dark 1997). In the southern Sierra Nevada, large-diameter trees and snags (conifers ≥ 112 cm, hardwoods ≥ 65 cm) were most frequently used for resting with California black oak comprising 40 percent of the rest sites (Truex et al. 1998). Similarly, Seglund (1995) and Dark (1997) found that fishers used large-diameter trees and snags on the Shasta-Trinity National Forest near the northern Sierra Nevada. In addition to the large size of trees and snags used as rest sites, many of these structures have suffered the type of stresses that initiate cavities and broken tops such as fire, disease, and decay (Zielinski et al. 1997c). Incidentally, these ecological processes that provide adequate refuge for fishers are often the same elements that are used to identify which trees or snags are likely to pose a hazard to forest workers.

All known natal and maternal dens in the western United States have been in large-diameter coarse woody debris, snags, or cavities of large-diameter live conifers or oaks (Powell and Zielinski 1994, Zielinski et al. 1997a, Truex et al. 1998). Previous studies have reported a negative association between detections of fishers and roads (Dark 1997, Golightly et al. in prep.). Theoretically, the removal of hazard and salvage trees near roads may have less of an effect on fishers. The removal of potential den site trees and snags could have a localized impact on the southern Sierra fisher population, especially if hazard and salvage trees are removed during the reproductive period. The extent of the impact depends upon the availability of other trees and snags with the specific size and structure of a resting or den site location. If trees and snags with resting den site characteristics are removed on a regular basis, however, fishers could be temporarily displaced or permanently extirpated from an area.

Impacts of harvesting hazard trees on foraging habitat and prey availability are likely to be insignificant because hazard trees are individual removals and are often conducted along roads or other areas affected by human presence. Fishers are opportunistic predators with a diverse diet, eating any mammal or bird they can catch and overpower (Powell and Zielinski 1994). In California, fisher diets include sciurids, woodrats, chickarees, mice, marmots, mountain beavers, quail, grouse, berries, carrion, and lizards (Zielinski et al. 1999, Golightly et al. 2006). While many of these prey species occur primarily in large trees and snags found in conifer and oak woodland habitats, the removal of single trees across a number of forest stands is unlikely to significantly affect the prey availability for a wide-ranging species. Prey populations may even benefit when felled trees are left to meet standards for the density of downed logs. In contrast, harvesting *salvage* trees may adversely affect foraging habitat and the availability of prey due to the clumped nature and extensive areas that may be affected by salvage removal.

Large hardwoods may also be an important source of mast that stimulates higher prey densities (Yeager 2005). Removal of mast-producing hazard and salvage trees would represent a short-term reduction. However, nearby trees would likely experience less competition for light, water, and nutrients. This would increase their mast production or their maturation rate, replacing the lost mast production.

Hazard Tree Removal

Hazard tree removal is the harvesting of all or a portion of a tree that has a great potential to fall or roll onto a roadway, trail, or facility and may cause personal injury or property damage. Trees are declared a hazard if they meet one or more of the following criteria: 1) dead (no live crown) or dying (more than 50 percent of crown foliage is discolored due to fire damage or disease); 2) compromised root system making it unstable; and/or 3) presence of insect activity. Merchantable portions of hazard trees are used for commercial timber sales. The remaining hazard trees are felled and left on site. Hazard tree removal is implemented to address concerns for public safety from the risk of hazard trees causing personal injury and/or property damage. In addition, the removal ensures that road systems are managed in accordance with applicable regulations, policy, and guidelines for public transportation safety.

Hazard tree removals usually occur around roads, recreation sites, administrative sites, and power lines, and trees are harvested singly or in stands up to 0.13 ha (1/3 ac) (M. Smith, pers. comm.). Hazard trees are also felled along fire lines if they pose a threat to fire fighters. Hazard tree removal generally does not consider the number of remaining snags within the stand or the potential contribution that felled snags could make to downed woody debris.

Hazard tree removal can be applied across all forest types and elevations where fishers occur. Hazard tree operations typically occur over multiple timber management stands and few trees might be felled within any given stand (M. Smith, pers. comm.). Site-specific information is generally known about each tree removed.

Because hazard tree removals generally occur adjacent to high human activity areas (e.g., active roads, campgrounds), trees removed probably provide little value to reclusive fishers. Also, the number of trees involved in hazard removal, especially the number that actually provide fisher resting or denning habitat, is probably inconsequential when compared to the number of trees impacted by other activities, such as timber harvest or forest fires. Consequently, hazard tree removal risks to fishers are probably low.

Fuelwood Collection

Fuelwood is harvested throughout the Sierra Nevada, with the exception that fuelwood collection is not allowed on National Park lands. Woody biomass is usually used for three purposes: 1) as fuel for power plants, 2) personal, subsistence, and commercial firewood use for home heating, and 3) commercial use for home heating by the pellet-stove industry (USDA Forest Service 2001). Fuelwood sources include natural dead and dying trees, timber harvest residues, and small, non-timber trees and shrubs removed to reduce fire risks. Conservatively, between 86,000 and 155,000 dry tons of fuelwood were sold (personal and commercial) from Sierra Nevada National Forests between 1990 and 1999. The Lassen National Forest contributes the highest amount of fuelwood among forests in the Sierra Nevada Forest Planning Area, but fuelwood collection on two forests currently occupied by fishers, the Sierra and Stanislaus National Forests, follow closely behind.

Commercial sales of non-timber biomass (small diameter trees that are chipped and used as fuel for power plants, or are shredded into excelsior) on Sierra Nevada forests is similar to fuelwood use, only with a much greater annual fluctuation. Between 1990 and 2002 biomass sales ranged between 33,000 and 1,126,000 dry tons annually. The majority of non-timber biomass sales occur on the Lassen and Plumas National Forests, although there are some sales on the Stanislaus National Forest within the current range of Sierra Nevada fishers.

Fuelwood collection has the ability to affect fisher populations adversely by removing the dead and down material used by fishers for denning and resting, while the non-timber tree removal associated

with biomass sales removes overhead cover and mistletoe resting sites. However, the amount of fuelwood annually made available for personal and subsistence use presents only a fraction of the annual woody biomass output. Further, personal and subsistence use is generally limited to within 100 feet of active roads or at timber sale landings, areas of low-likelihood use by fishers anyway. Finally, non-timber biomass collection conducted as part of a fuels reduction program greatly reduces the risk of catastrophic wildfire, an agent of greater threat to local fisher populations.

Defensible Fuels Profile Zones

Defensible Fuels Profile Zones (DFPZs) are strategically located strips of land of variable width where the vegetation has been modified to a less dense fuel type. DFPZs are generally located along ridgetops, roads, and other places where firefighters could make a stand to contain a wildland fire. DFPZs are not designed to stop an oncoming fire by themselves; they provide a safe location for indirectly attacking wildfires and providing an anchor point for prescribed burning projects (Green 1977, Omi 1996, Agee et al. 1999). They are typically placed in wildland-urban intermix zones. The HFQLG ROD provides direction for constructing up to 120,000 ha (300,000 ac) of DFPZs on the Tahoe, Lassen, and Plumas National Forests.

DFPZs have less surface fuel and the bases of live tree crowns are higher off the ground than the surrounding forest. Reduced surface fuels, open understories, and the increased distance between the ground and overstory tree crowns interrupt the pathway between a surface fire and the forest canopy (Agee et al. 1999). The forest canopy in the DFPZ may be reduced to 40 percent closure. Snags that could block access roads or escape routes or snags that create hazards to personal or public property are removed from DFPZs. Snag and large woody material retention levels are usually determined locally on a site-specific basis to balance wildlife habitat objectives with fire hazard reduction objectives.

As described above, DFPZs will be concentrated in defense zones of the wildland-urban intermix zones. DFPZs are intended for maintenance as a long-term feature of the landscape. This means that maintenance treatments would be conducted on a 10 to 20 year re-entry schedule. While DFPZs in the HFQLG Pilot Project Area will be constructed outside defense zones, adherence to SNFPA ROD standards and guidelines for fuels treatments will minimize impacts to large tree and canopy cover elements of stand structure. The degree to which defense zones overlap with the fishers' elevational range and important forest types (including hardwoods) is not clear, although most defense zones in the HFQLG area occur in areas not currently supporting fishers (although they may have historically). Given this, and that at least 40 percent canopy coverage will be maintained, DFPZs do not appear to pose a threat to fishers. Additionally, reversal of this canopy cover based treatment can occur quickly, with shrub cover regeneration periods of three to five years.

Prescribed Fire Management

Prescribed fire is defined by the National Interagency Fire Center as "any fire ignited by management actions to meet specific objectives. A written, approved prescribed fire plan must exist, and NEPA requirements must be met, prior to ignition" (Zimmerman and Bunnell 1998). Underburning, a broadcast use of fire to remove fuel buildup and prepare grounds for regrowth, is the most common method of prescribed fire. Slash pile burning is also used.

Underburning

Prescribed burning occurs on both National Park and National Forest lands in the Sierra Nevada. Sequoia and Kings Canyon National Park in the southern Sierra was one of the first parks to use prescribed fire and continues to use underburning to reduce the risk of wildfire by removing fuels, as well as to attempt to restore fire as a natural ecosystem process (Pyne et al. 1996). In 1979, the National

Forests began moving from a policy of nearly complete fire suppression to using prescribed underburning as a tool to prevent catastrophic wildfire.

While the Forest Service and National Park Service bear the responsibility for nearly all fire management efforts on federal lands in the Sierra Nevada, the California Department of Forestry (CDF) provides fire protection primarily for roaded private lands (Husari and McKelvey 1996). CDF protects much of the lower-elevation lands in the Sierra foothills as well as large areas of private timberlands. These lands dry earliest and have the longest fire season (McKelvey and Busse 1996). CDF also protects state parks and other state-owned lands. CDF conducts prescribed burns cooperatively with landowners through the vegetation management program, which is designed to reduce large, damaging wildfires by reducing fire hazards on wildlands. Most prescribed burning under the vegetation management program has focused on standing brush, but policies are under consideration that would expand the program to include other fuel types, for example, understory burning. Between 1981 and 1996, an average of about 4,775 ha (11,800 ac) were burned annually under the vegetation-management program (Husari and McKelvey 1996). By comparison, the FEIS for the Sierra Nevada Forest Plan Amendment provides a combined planning projection of approximately 14,160 ha (35,000 ac) of prescribed burning and wildland fire use during the first decade on National Forest System lands in the Sierra Nevada.

Great effort is made to plan and control the extent and intensity of a prescribed burn, and natural fire intervals are mimicked as much as possible (Pyne et al. 1996). In general, prescribed burns can help avoid catastrophic stand replacing fires and ultimately promote forest health. This practice often provides habitat of increased suitability for wildlife—especially if fire does not coincide with the breeding season of a species (Walstad et al. 1990). However, fires might burn out of control and move beyond anticipated boundaries. Although relatively small fires are theorized to create few problems for mammals with relatively large home ranges (such as fishers), large fires are thought to displace these species, at least temporarily, from an area (Walstad et al. 1990).

Generalizing the risks to fishers associated with underburning is difficult because the size and intensity of individual prescribed burns are variable. Additionally, very little research has been done related to fishers and fire, making it difficult to assess potential impacts. Direct and indirect effects on fishers can be inferred from a few studies on martens and fire in other parts of North America (Koehler and Hornocker 1977, Latour et al. 1994, Paragi et al. 1996); the potential effects of fire on prey, coarse woody debris, and snags/trees used for rest sites (Tevis 1956, Spencer et al. 1983, Walstad et al. 1990, Corn and Raphael 1992, Werner 2000); and the need to maintain connectivity between patches of suitable habitat due to both species' associations with high percent canopy cover (Chapin et al. 1998, Carroll et al. 1999).

Based on the habitat and food requirements of fishers, it seems unlikely that low-level, controlled underburning would pose a serious risk to this species. Low-level fires can, but do not necessarily, consume large-diameter coarse woody debris and snags, and they often leave a high percent of canopy cover, and unburning may stimulate production of key prey. Prescribed fire should be considered a risk factor only because of the remote chance of the fire consuming an active den, and the associated risk of a burn becoming uncontrolled. These risks, however, can be managed in the planning process for the underburn.

Slash Pile Burning

Another method to remove accumulated fuels after timber harvest or thinning is to pile the slash and then burn. Very little direct information exists regarding how pile burning might pose a significant risk to fishers; thus, it is difficult to determine whether this should be considered further as a risk factor. As

with underburning, so little research has been done on the subject that at least cursory consideration is warranted.

Some of the same issues associated with underburning apply to pile burning. pile burning typically is conducted after a logging operation to reduce fuel loads and/or prepare a site for replanting or regeneration. The burning is planned and thus can be influenced to a large extent by management; however, like other fires, these operations can sometimes burn out of control. In general, it seems unlikely that pile burning would be conducted in sensitive areas for fishers, unless the animals were specifically denning within the pile. It seems more likely that pile burning might affect fishers indirectly by reducing the number of cover objects for prey; however, this would depend on the surrounding habitat.

Use of slash piles by fishers as resting sites has been reported by Buck et al. (1983) and Weir et al. (2004), but compared to other structures, slash pile use appeared rare, and no records of slash piles being used as denning sites were found. Consequently, slash pile burning has little potential for directly impacting fishers, and only a low potential for indirectly affecting habitat of key prey.

Wildland Fire Use

Wildland fire is defined by the National Interagency Fire Center as "any nonstructure fire, other than prescribed fire, that occurs in the wildland." Wildland fire use is characterized as "the management of naturally ignited wildland fires to accomplish specific prestated resource management objectives in predefined geographic areas outlined in Fire Management Plans."

Wildland fire use is similar in many ways to prescribed underburning (described above). There is little research regarding its potential effects on fishers. Wildland fires are used most frequently by the National Park Service in designated areas (typically remote). Wildland fires are also used on National Forest lands, generally in wilderness areas when they help to meet management objectives (for example, fuels reduction) while minimizing unacceptable consequences to the environment or to health and human safety.

Wildland fires differ from prescribed burns in that the location of the fire originates from a natural source (usually lightning), and these burns have not been subjected to the rigorous planning process of traditional prescribed burns. Although management does have some influence over these fires, it is not to the same degree as that for prescribed underburns. Wildland fires used to meet resource objectives have the same potential risks as prescribed underburns for fishers and will vary greatly in their extent, intensity, timing, and duration. Because fire is part of the natural regime in forested environments, fishers would have been exposed to risks associated with wildland fire in an unmanaged environment. As such, wildland fire use should not be considered a serious risk relative to other risk factors confronting fishers considered in this assessment.

In general, managed wildland fires are likely to benefit fishers by preventing catastrophic wildfires and promoting forest health. However, such fires can be quite destructive if the weather changes or fuel loads in an area are excessively high due to previous fire exclusion. Major risks are described under prescribed underburning above, and they include direct mortality and indirect effects on habitat, such as loss of snags, canopy cover, coarse woody debris, and connectivity of suitable habitat across landscapes.

Catastrophic Wildfire

Many researchers recognize a dramatic shift in the frequency and intensity of wildland fire in the Sierra Nevada, compared to historical fire regimes (Lenihan et al. 2006). In many areas (particularly at lower elevations), the historical pattern was characterized by short-interval, low-to-moderate severity fires. These frequent fires slowed down the accumulation of fuels such as dead branches and litter. Fire exclusion has resulted in increased germination and survival of fire-sensitive trees which now occur at densities greatly exceeding the historical averages generated by the occurrence of periodic low-intensity fires (McKelvey and Busse 1996, Skinner and Chang 1996). In addition, periodic low-intensity surface burning likely created uneven-aged stands made up of even-aged groups of trees of various age classes (Skinner and Chang 1996). The resulting landscape was characterized by forests that occurred in spatially complex patterns with mosaics of patches with different levels of structure, and with non-distinct boundaries (USDA Forest Service 2001 - Part 3.2). With the advent of Euro-American settlement and widespread fire suppression, fires have become less frequent, and the build-up of fuels has allowed very hot fires that can kill large areas of mature forest (Weatherspoon et al. 1992). As a result, today's wildfires result in more dramatic habitat changes than previously, with fewer inclusions of remnant forest that has been less severely affected by low-intensity burns.

This shift is particularly evident in the lower elevations of the mixed-conifer zone, where ponderosa pine is often dominant (Skinner and Chang 1996). In the southern Sierra Nevada, such areas potentially provide suitable habitat for fishers, which generally occur between 1,000 and 2,130 m (4,900 and 7,000 ft) elevation (Golightly et al. 2006, Zielinski et al. 1997a). Sapsis et al. (1996) determined that much of the front country and Sierra foothills faces a high risk of being burned by large (more than 120 ha [300 acres]) fires, while high elevation areas of sparse, discontinuous fuels show significantly lower rates of large fire incidence.

Skinner and Chang (1996) surmise that pre-settlement landscape patterns in the mixed conifer zone were of a relatively fine scale, compared to today, and that many forested areas were generally more open, due mostly to the frequency of fires. Large landscape patterns of relatively homogeneous multilayered forest stands were probably uncommon before the twentieth century (Skinner and Chang 1996). Pre-settlement forest conditions fostering low- and variable-intensity fires likely resulted in the inclusion of patches of denser vegetation amid more open areas. Fishers appear to use habitats with equal to or less than 40 percent canopy closure if sufficient clumps of denser vegetation are present with large legacy elements for rest sites (Buskirk and Powell 1994). Regardless of the level of habitat suitability under the pre-settlement fire regime, it is generally understood that the risk posed by large, high-intensity fires far exceeds that associated with frequent low- and moderate-intensity fires, or with most prescription burning.

The largest events affecting fishers in the southern Sierra and their potential to sustain a viable population appear to be large, stand-replacing wildfires. Large wildfires affected fisher habitat in large patches across the Sierra Nevada in the past, and resulted in a large barrier to northward movement of fishers on the Stanislaus National Forest. More recently, several large fires on and around the Sequoia National Forest have resulted in increased habitat fragmentation and decreased habitat quality in one of the few areas with known fisher populations in the Sierra Nevada. The McNally fire in 2002, for example, burned approximately 62,750 ha (155,000 ac), approximately 6,900 ha (17,000 ac) of which were stand-replacing intensity within suitable and presumed occupied fisher habitat. Such losses may have repercussions for recovery efforts range-wide, for instance, by reducing the number of animals available for reintroduction elsewhere. Analyses conducted for the Final Supplemental EIS for the Sierra Nevada Forest Plan Amendment indicate an upward trend in the annual amount of area burned by wildfires in

the last 30 years, a trend that is likely to continue in the absence of vegetation and fuels management activities designed to reverse this trend.

Chang (1996) summarized faunal responses to fire for the Sierra Nevada Ecosystem Project, and found that fire may result in direct mortality of some of the small mammals that constitute much of the fishers' diet, especially non-burrowing species. The indirect effects of fire—particularly the frequent, low-intensity fires that typify the historical fire regime of the Sierra Nevada, and that may be approximated by prescribed burning—are generally considered less detrimental. Vegetative biomass increases shortly after fire, leading to a greater abundance of food, cover, and structural heterogeneity, which may in turn lead to increased populations of some species (Chang 1996). Fishers are opportunistic predators with a diverse diet, and may switch prey in response to changing densities (Kuehn 1989, Zielinski et al. 1999, Bowman et al. 2006). Fire may result in decreased availability of some prey species, but fishers are likely to find sufficient food from other sources.

Working in Sequoia National Park, Caprio and Swetnam (1995) found that most fires on the western slope of the Sierra Nevada historically occurred late in the growing season, probably from mid-summer to early fall (in the southern Sierras, unstable spring weather conditions often result in a high incidence of lightning fires, particularly after low-snowfall winters). This general pattern appears to be similar to the modern fire season, with the highest fire incidence occurring during July, August, and September (Sequoia and Kings Canyon National Parks draft Fire and Fuels Management Plan, 2003). Skinner and Chang (1996), however, speculate that the introduction of non-native annual grasses and herbaceous vegetation may have promoted an earlier onset to the burning season during the twentieth century. In contrast, most prescribed burning takes place in spring (mid-April through mid-June) and fall (mid-September through mid-November). Spring and summer correspond with the periods of denning and rearing for fishers. Fires that occur during the peak burning season thus pose an elevated risk of killing or displacing denning females or kits. Also, summer fires in low-moisture fuels may burn more intensely and result in more dramatic changes to habitat than fires in spring and autumn, when fuel moisture is higher.

Another key difference between wildland fire and prescribed fire is the planning that precedes the latter. Whether caused by lightning or human carelessness (or malice), wildland fire ignitions are a stochastic event. As such, wildland fires may occur at any time in any location, but are most likely to occur during periods of warm and dry weather, particularly during drought years (McKelvey and Busse 1996). In contrast, extensive planning precedes prescribed burning, which is typically scheduled during periods when fuel moisture is low enough to allow ignition but not so low as to present a significant risk of developing into a large, high-intensity fire. Burning units can be laid out to avoid known sites important to key species (e.g., den and/or resting sites). Perhaps more importantly, prescribed burning can be designed and scheduled to minimize the risk of high-intensity fires that render large areas of habitat unsuitable for fishers. Lastly, most prescribed burning activities are implemented at a fine scale, allowing for relatively quick recovery compared to the much larger and more disruptive effects of stand-replacing disturbances that such actions are intended to reduce. Omi and Martinson (2002) found that treated stands experience lower fire severity than untreated stands that burn under similar weather conditions and topography.

Fire Suppression Activities

Suppressing a large wildfire involves the mobilization of a great number of people and equipment, which can have a profound impact on the local environment. Wildfire suppression can involve 1) hundreds of firefighters occupying the forest environment, 2) development of new roads to move equipment to the fire line, although this action is extremely rare, 3) construction of fire breaks, 4) use of loud noise-

generating equipment such as aircraft, chainsaws, and generators, 5) aerial application of fire retardant, 6) draining of water resources from impoundments, and 7) increased traffic on local roads and highways from fire-support teams. Most fire suppression impacts, however, are short-termed, and any fishers encountering noise and humans are probably already stressed from the onset of the wildfire. Wildfire suppression impacts may also be mitigated if they result in the preserving of key fisher habitat from wildfire loss. Stand-replacing wildfires leave little, if any, fisher habitat (given fishers' predilection for closed canopy forests) remaining. The potential negative impacts of fire suppression activities to fisher ecology are probably of low concern.

Climate Change

Recent projections by the Intergovernmental Panel on Climate Change (IPCC 2001) show a doubling of atmospheric carbon dioxide (CO_2) from industrial sources by as early as 2050. Climate responses to increased CO_2 vary regionally, depending on topography, but a universal trend towards warming is expected due to trapping of heat by greenhouse gases. California is especially vulnerable to climate change due to the coastal and latitudinal orientation, great elevational gradient, and a wide variety of ecosystems (Snyder et al. 2002). Because the state's ecosystems are already stressed by human growth and agricultural demands, the added stress from climate change could greatly alter the current biotic landscape of California.

Snyder et al. (2002) modeled climate change for California based on a projected doubling of CO_2 and concluded a warming would occur across the state with the greatest temperature changes in the Sierra Nevada (where average annual spring temperatures could increase by as much as 6°C). In general, the winters are expected to become warmer and wetter (with decreased snow precipitation), and the summers hotter and drier. Warmer and wetter winters (combined with increased CO_2 levels) could result in faster growth (recovery) of forest habitats and expansion of mid-elevational forest habitats to higher elevations. Lenihan et al. (2006) also looked at the responses of vegetation distribution to three future climate scenarios in California and too found predicated dramatic increases in mid-elevation mixed evergreen forests (conifer/oak), mainly as a result of increased temperatures. But Lenihan et al.'s models also predicted decreases in conifer forests (pine/mixed conifer) due to increased fire. In fact, Lenihan et al. (2006) predicted that relative to the past century, annual area burned would increase 10 to 50 percent for the period 2050 to 2099, which could result in a dramatic loss of overall forest canopy coverage.

Predicted climate change over the next century could benefit fishers by 1) decreased snow levels given the animal's tendency to avoid deep snow (Raine 1983, Arthur 1989a, Aubry and Houston 1992), 2) increased rainfall during the growing season resulting in increased productivity, and 3) upslope expansion of the mixed evergreen forest habitats in which fishers are often found in the southern Sierra Nevada and the Klamath region of northern California (Self and Kearns 2001, Klug 1997, Higley et al. 1998, Zielinski et al. 2004a, Yeager 2005). Conversely, the predicted hot dry summers could lead to a great increase in stand-replacing fires, especially if wet and warm winters and springs lead to increased fuel loading. These fires could contribute greatly to habitat fragmentation, especially in coniferous forest habitats, and to the loss of fisher population viability. Lenihan et al. (2006) predicted that due to increased fire and changes in moisture regimes, continental conifer forests would be replaced by more fire-tolerant mixed evergreen forests with oak components. Thus, future climate change may result in an increase of the forest types in which fishers in the southern Sierra Nevada and northern California are currently found, at the expense of mixed conifer forests in the Sierra Nevada traditionally thought as prime fisher habitat. However, forest conversion may require the intermediate step of a stand-replacing fire (and the subsequent complete, but temporary, loss of fisher habitat), and the subsequent maintenance

(by fire) of a more open-canopied forest less suitable to fishers (basically the conversion to the right forest type but the wrong forest structure).

Further, climate change may affect the ability of fishers to expand their current range. The extant fisher population in the southern Sierra Nevada exists is the animal's southernmost extent, where increased temperatures have the greatest impact. If the existing population's ability to expand northward is limited by forest fragmentation or natural river barriers, then climate change may eliminate these populations before the barriers limiting expansion are lifted (e.g., before forest succession improves habitat in fragmented areas, or the episodic freezing or drought conditions occur allowing fishers to cross river barriers).

Whether modeled climate change would benefit or adversely affect fishers over the long run is unclear, and may depend on the interactions of other factors influencing fisher conservation. It is likely, however, that the future will challenge fishers' ability to adapt to a changing Sierra Nevada climate and ecosystem.

Livestock Grazing

Cattle and packstock grazing is permitted on National Forest and private lands throughout much of fishers' historical and current range in the Sierra Nevada Forest Planning Area. Grazing can remove vegetative cover used by fishers and can degrade meadow and riparian habitats and compact soils, adversely affecting prey species (USDA Forest Service 2001). However, grazing practices today are much more controlled than the past (Menke et al. 1996, Allen-Diaz et al. 1999), and fishers essentially avoid the meadow and other open habitats favored by livestock. Further, predator control, a secondary aspect of grazing, is no longer permitted in a manner where there is a significant risk of incidental fisher mortality. Subsequently, current grazing practices in the Sierra Nevada pose little risk to fisher population viability, with the caveat that grazing can reduce important understory habitat in riparian areas, habitats found to be important to fishers, at least in British Columbia (R. Weir, pers. comm.).

Recreation

Recreational activities can affect wildlife species; however, this relationship is poorly understood (Knight and Gutzwiller 1995). Recreational activities can alter wildlife behavior, displace wildlife from preferred habitats, decrease reproductive success, and decrease individual vigor. Peak recreation activity levels often coincide with the most critical phases of the species' life cycle, such as breeding and reproduction. It is unclear how results from studies of recreation effects on other species might apply to fishers.

Off-highway vehicle (OHV) use occurs throughout the historical range of the species in the Sierra Nevada Forest Planning Area and, although fishers occur mainly below snowline, over-snow vehicle (OSV) use and fisher populations may coincide. One of the fastest growing activities in the United States during the period from 1982 to 2001 was the operation of "off-road" motorized vehicles (Cordell et al. 2005). In California, from 1976 to 2002, the number of registered OHV/OSVs increased by 108 percent (California Department of State Parks and Recreation 2002). Human presence and noise can lead to behavioral changes. Motorized recreation may affect winter survival and disturb fishers during the breeding season and as they disperse. Human activities that lead to changes in wildlife community composition may result in increased competition for food resources or introduce new predation pressures to fisher populations (Joslin and Youmans 1999).

Zielinski et al. (2007) found that closely-related American martens seemed indirectly unaffected by the level of OHV/OSV use in two Sierra Nevada study sites. While the authors qualify their results with a need for assessment of potential direct effects in terms of metabolic rate, etc., the frequency of

spatial and temporal disturbances from OHV/OSV did not appear to pose a threat to marten; study animals did not change their landscape use, circadian activity pattern, or population sex ratios as hypothesized (Zielinski et al. 2007). The martens may have habituated to the disturbance or not have perceived the threat as great enough to warrant the risks and energetic expenses associated with relocation. Given that population viability is a function of habitat quality, quantity, and distribution, it is, however, possible that the effects of OHV/OSV use may interact cumulatively with other threats to affect fisher population persistence (Zielinski et al. 2007).

Jones (1991) frequently observed fishers in Idaho feeding on bird and squirrel foods left upon window ledges of homes. Generally, wildlife exhibit three learned responses to humans, described by Knight and Cole (1995): habituation, attraction, and avoidance. Animals habituate to humans only after repeated stimulation (Joslin and Youmans 1999). Physiological responses of some wildlife to natural as well as human-caused disturbances include elevated heart rate, metabolism, blood sugar, respiration rate, and more; each of these responses levies an energetic cost to the animal (Gabrielsen and Smith 1995).

Animals habituate at the energetic cost of repeated stimulation in addition to exposure to elevated risk of mortality in the form of aggressive interactions with domestic pets and their diseases, risk of incidental mortality from a variety of sources, or being struck by vehicles (Joslin and Youmans 1999). Animals attracted to food sources provided by humans may experience poor nutrition as a result as well as elevated risk of mortality (Joslin and Youmans 1999). Individuals that actively avoid human activities do so at the energetic costs of repeated disturbance, and even abandoning available resources in the disturbed area (Joslin and Youmans 1999).

Presence of domestic dogs may result in direct or indirect mortality of kits or exposure to disease (Joslin and Youmans 1999). Canine and feline distemper have been known to cause localized high mortality of fishers (Joslin and Youmans 1999). The presence of these diseases and others in fisher populations in northwest California has been documented by Brown et al. (2006). Indeed, dogs are run as a recreational sport in California by private individuals and for bear hunting by outfitter guides operating under NFS permit. These dogs have treed fishers on a number of occasions (S. Anderson, pers. comm.). Neither the degree of stress this activity places on individual fishers, nor the effects to fitness are known. Mortality rates resulting from capture by dogs are similarly unknown.

Development and Urbanization

In general, extensive development and urbanization has not occurred within the current and historical ranges of the Sierra Nevada fishers. Even the extensive development in the Tahoe/Reno area, and the number of ski resorts along the western slope of the Sierra Nevada probably pose little direct risk to fishers. Each is confined to a small area or narrow corridor (perimeter of Lake Tahoe) relative to the habitat available elsewhere for fishers. These developments, however, have contributed to increased travel along the highways, thereby increasing the threat of mortality and habitat fragmentation.

Human development can also introduce population sinks where mortality exceeds reproduction. Skeletons of eight fishers were discovered in a single abandoned water tank in northwestern California located in a second-growth forest of redwood, Douglas-fir and tanoak with scattered large legacy trees (Folliard 1997). The point of entry consisted of a 0.46 meter square opening centered on the top of the structure, from which no means of escape in the form of a ramp, traction on the walls, or other exit hole existed, effectively rendering the cylindrical 4.0 m long by 2.3 m diameter tank a lethal trap for fishers (Folliard 1997). Interestingly, only curious fishers became trapped in this tank; if other species investigated the interior of the tank, they managed to escape. A similar incident occurred on the Sequoia

National Forest, where one fisher became trapped and died in a cistern associated with a recreation residence (R. Galloway, pers. comm.).

Highways, Roads, Railroads, and Trails

Roads affect fishers in the following ways: (1) vehicles traveling at high speeds kill animals, potentially increasing mortality rates (see Road Mortality); (2) major highways can contribute to habitat fragmentation because fishers generally avoid entering open areas that have no overstory or shrub cover; and (3) roads, and the associated presence of vehicles and humans, cause animals to modify their behavior near roads (USDA Forest Service 2001). These direct impacts and indirect effects on habitat could negatively affect fisher populations.

Previous studies have reported a possible negative association between detections of fishers and roads (Dark 1997, Golightly et al. 2006). Road construction associated with timber harvest activities could directly and indirectly affect fishers. Direct effects may stem from the direct loss of resting or denning structures. Indirect effects would include long-term exposure to vehicle traffic on roads constructed or improved for harvest activities. If fishers avoid areas in proximity of roads, then these areas constitute habitat loss. Indirect effects would also include the lasting effect on prey populations that may also avoid or be killed by vehicle traffic.

By virtue of the fact that major highways represent wide, open areas, fishers might not chose to cross them due to their general avoidance of areas lacking overhead cover. Consequently, highways may act as a movement barrier to dispersing fishers, which can lead to habitat fragmentation and population isolation. However, Aubry and Raley (2006) found that fishers in southern Oregon regularly cross Highway 62, although the highway did influence spatial use.

Roads, and even trails, represent areas of high human and motorized activity, including snowmobile activity in the winter and dogs. Rather than adapt to these activities, fishers may choose to avoid them such that roads and trails, and some distance beyond them, represent linear strips of reduced suitability habitat. Trails may, however, also provide easy travel routes for fishers during periods of low seasonal or daily human activity.

Finally, two railroads, the Union Pacific and the Southern Pacific, bisect the Sierra Nevada and potential fisher habitat. The relatively slow speeds of the trains that use these railways probably preclude the likelihood of collision with fishers, but the railroad right-of-way might pose a limited barrier to fisher movement. However, both railroads lie outside the current Sierra Nevada range of fishers, and probably pose a very low impediment to future fisher dispersal.

Impoundments and Canals

Reservoirs and canals affect wildlife by: 1) blocking or impeding dispersal and migration movements, 2) inundating riparian and upland habitats, 3) increasing disturbance from human activity, and 4) blocking migration of aquatic prey (e.g., fish) (Stull et al. 1987). Although there are reports of fishers crossing rivers, wide rivers are thought to at least be impediments to movement (Powell 1993). Thus, reservoirs with long arms, or deep, fast-flowing water canals may, like some rivers, act as impediments to fisher movement and contribute to habitat fragmentation. Shasta Lake on the Shasta-Trinity National Forest is an example of an impoundment where reservoir configuration has the potential to impede wildlife movement and fragment habitat. However, most large water impoundments in the Sierra Nevada, and associated open canals, occur in the lower foothill regions of the mountain range largely outside fishers' elevational range and thus probably pose little risk to fisher ecology.

Utility Corridors

The effects of utility corridors on fishers and their habitat are probably similar to, but less severe than, those of roads. In general, utility corridors are less common and receive less human and vehicle traffic than roads. However, like roads, they contribute to habitat loss and fragmentation. Powerline right-of-ways are often treated with herbicides to control vegetation. Some herbicides have the potential to biomagnify or bioaccumulate in higher order predators such as fishers. In general, however, the miles of utility corridors found within the current or historical range of fishers in the Sierra Nevada are probably not great enough to warrant a population concern, and although corridors may inhibit movement, they are unlikely to stop fisher dispersal.

Factors Affecting Populations and Individuals

Direct and indirect mortality of individuals can lead to impacts at the population level. While direct mortality factors, such as trapping and incidental poisoning have been responsible for past population declines, these factors are not operating today at past levels. Nevertheless, since the loss of even a few individuals is significant in a small and declining population, any factor potentially affecting individuals must be examined and evaluated closely.

Incidental Trapping

Trapping can be the most significant source of mortality for fishers where fisher trapping is permitted (Powell 1993). Fishers are easily trapped and pursuit of their highly valued pelts greatly attributed to their decline in California (Dixon 1925, Grinnell et al. 1937, Lewis and Zielinski 1996). Powell (1979) estimated that as small as a one to four individual fisher increase in annual mortality due to trapping per 100 km^2 could precipitate a population decrease in the eastern populations he studied.

Lewis and Zielinski (1996) examined California trapping records prior to the fishers' protection in 1946 from commercial harvest and concluded that a significant number of captures were by generalist trappers not specifically pursuing fishers. Their results challenged an earlier view by Grinnell et al. (1937) that overtrapping by fisher specialists was primarily responsible for fisher decline. Lewis and Zielinski (1996) concluded that a small number of fisher specialists and a large number of generalist trappers pursuing other carnivores, but incidentally capturing fishers, accounted for the patterns they observed in the harvest data.

To understand better the role of incidental capture on fisher mortality, Lewis and Zielinksi (1996) interviewed five commercial trappers, representing 21 trapping seasons, and learned that 72 fishers were incidentally captured in nearly 51,000 trapping set-nights. At least 17 of the captured fishers died or were injured from the encounter. Because the five trappers represented but a small sample of California trappers at the time (over 300 trapping licenses for the 1994-1995 season), and trappers may be reluctant to report the capture and condition of a protected animal, the true magnitude of the incidental capture on California fishers could not be assessed accurately (Lewis and Zielinksi 1996).

Currently, incidental capture of fishers by commercial and recreational trappers in California may be of little issue. In 1998, voters in California passed Proposition 4 banning the use of body-gripping (e.g., leg-hold, snares) traps to capture fur-bearing animals for the purposes of commercial or recreational harvest. This restriction, plus other California Fish and Game protective regulations, effectively eliminates the incidental mortality concerns by legal fur trapping. Illegal harvest threat remains, but is probably not a significant source of mortality.

Predator Control

Just as commercial harvest targeting other species has been deemed a significant source of incidental mortality for fishers in the early 1900s (Lewis and Zielinski 1996), trapping and the use of strychnine bait to control coyotes (*Canis latrans*), wolves (*Canis lupus*), and other predators during this time period probably also contributed to the incidental loss of fishers (Wild and Roessler 2004). Fishers are easily trapped, and probably were easily poisoned, especially where meat was used as bait. Carrion is an important dietary component (Powell 1993, Zielinski et al. 1999), and carrion bait would easily attract fishers.

Currently, use of poisons to control predators has been banned, and any trapping to protect livestock within the range of fisher populations would likely be conducted by professionals with the USDA Animal and Plant Health Services-Animal Damage Control (APHIS-ADC). Because APHIS-ADC personnel use trapping methods to target offending animals specifically, and most predator conflicts occur in open grazing country where fishers do not occur, incidental capture of fishers from professional predator control is very remote. Unsanctioned predator control activities may be occurring on private lands; however, the level and degree to which these activities occur in fisher habitats are unknown.

Pesticides and Toxins

Intensive programs to control pocket gophers, ground squirrels, and porcupines were conducted in the Sierra Nevada in the 1950s through 1970s, resulting in secondary poisoning of many mesocarnivores (Barrett 1997). These programs could have had a profound impact on Sierra Nevada fisher population declines either directly (secondary poisoning) or indirectly (loss of rodent prey populations). The impact of past porcupine control on Sierra Nevada fishers may be seriously underestimated.

Currently, rodenticides are used on public and private lands to protect vegetation and control plague. The most widely used chemicals are strychnine, a convulsant used to control pocket gophers in plantations, and diphacinone, a first-generation anticoagulant used to control ground squirrel and chipmunk populations primarily in response to plague outbreaks in recreation areas where risk of contact with humans is greatest. Historically, strychnine use resulted in high mortality rates of non-target species (Linsdale 1931, 1932). Baiting at this time was rather casual, involving broadcast distribution of poisoned grain on the ground (Linsdale 1931). Current pesticide-use protocols are more precise and seek to limit non-target species mortality. Treatments for pocket gophers on federal lands must occur underground, using an injection system, with no baiting at the surface. Gophers are solitary and territorial and tend to die underground in the burrow system (Hegdal and Gatz 1976, Fagerstone et al. 1980). However, following an underground treatment for pocket gophers in Oregon, Anthony et al. (1984) found dead, non-target ground squirrels with enough strychnine in their GI tracts to poison mink lethally if ingested. Fagerstone et al. (1980) also noted impacts to non-target small mammals following underground application for control of pocket gopher. Yet, given that only about 2,000 ha (5,000 ac) per year are treated using strychnine on National Forest lands in California (D. Bakke, pers. comm.), and the precautions that are taken to avoid poisoning non-target species by following proper application and monitoring, the risk of strychnine secondary poisoning of fishers is low, at least on public lands.

Use of anticoagulants, such as diphacinone, may represent a greater potential threat to fishers because these baits are typically applied above-ground. Anticoagulants are used to target rodents which are commonly found in fisher diets, and secondary poisoning is possible if a predator consumes the GI tract or cheek pouches of poisoned rodents (Mendenhall and Pank 1980, Hegdal et al. 1981, Littrell 1990). However, Forest Service use of diphacinone has been greatly reduced in recent years after peaking in

1995-1996, and its use is very limited in extent. Consequently, the potential for secondary poisoning impacts from diphacinone on fishers is probably very low.

Rodent control programs can also affect fishers by reducing prey species. Many of the species killed in rodent control programs are commonly found in Sierra Nevada fisher diets (e.g., pocket gophers, ground squirrels, and deer mice; Zielinski et al. 1999). However, current rodent control programs are so limited that dietary impacts to fishers are remote.

Diseases and Parasites

Fishers, like all mesocarnivores, are susceptible to a number of diseases and parasites. Diseases include rabies, plague, canine and feline distemper, toxoplasmosis, leptospirosis, trichinosis, and Aleutian disease (Strickland et al. 1982, Wild and Roessler 2004). Banci (1989) noted fisher susceptibility to sarcoptic mange. Common endoparasites include nematodes, cestodes, and trematodes, and ectoparasites fleas, ticks, and mites (see Powell [1993] for an extensive list of known parasites). However, none of these diseases or parasites has been thought to constitute a significant source of mortality (Lewis and Hayes 2004), possibly because of a weak transmission pathway due to fishers' solitary nature (Coulter 1966, Powell 1977) and tendency to avoid proximity to other individuals (Powell 1977, Arthur et al. 1989a). Recent studies (Brown et al. 2006) on the Hoopa Valley Indian Reservation in northern California, however, may challenge these premises. Researchers here tested 53 fishers and found the presence of potentially lethal West Nile virus, canine distemper virus, canine adenovirus, canine herpes virus, parvovirus, and an 83 percent exposure to *Anaplasma phagocytophilum*, a tick-borne infectious agent for the potentially lethal granulocytic anaplasmosis. The presence or extent of these diseases in Sierra Nevada fisher populations is unknown, but testing and monitoring is probably warranted, especially if translocation of (potentially infected?) populations is considered as a conservation measure.

Road Mortality

Vehicular collision is a recognized source of fisher mortality (Heinemeyer 1993), and is probably second to trapping as a source of non-natural death in the North American range of fishers. Approximately 3.4 percent of 147 radio-collared fishers studied in Massachusetts (York 1996) and Maine (Krohn et al. 1994) were killed by vehicles. Presumably the risk of collision mortality increases with the density of highways and freeways where vehicle speeds are highest and the ability of driver or fishers to avoid a collision is lessened. This may be an especially important factor in the Sierra Nevada where a dozen highways and Interstate-80 intersect current and former fisher habitat, with an average of only about 50 km separating each. Subsequently, dispersing fishers might not be able to avoid crossing highways and encountering the associated hazards therein. Interstate-80, with its jersey barriers, steep fills, and other impediments to fisher crossing may be particularly hazardous to dispersing fishers. In general, the importance of roads to Sierra Nevada fishers is currently difficult to quantify, but highways in particular have the potential of being a very important risk factor.

Research Activities

Although research does not appear to pose a significant risk to fisher populations, research activities can pose a temporary or permanent risk to individual animals (Samuel and Fuller 1996). While mortalities and injuries to fishers during research projects in North America have been infrequent, they can and have occurred. Capture and handling, especially when using immobilizing drugs, of any wild animal can pose risks, and adding the additional burden of ear tags or radio-transmitters can have unintended consequences (Samuel and Fuller 1996) in terms of entanglement, strangulation, or reduced ability to capture prey and avoid predators.

Researchers and managers can minimize these risks through awareness of previous problems and understanding of the safest current methods of capture, handling, and tracking (Arthur 1988, Bull et al. 1996). Powell and Proulx (2003) recently developed performance criteria for the ethical and common sense capturing and marking of animals that researchers can use to for effective and safe handling, thereby minimizing risks both to animal welfare and unbiased data collection. Potential risks to fishers due to current research are likely minimal and are limited to a few individuals, largely because of the professional standards generally followed; however, any loss from a research incident is significant where small, stressed populations are concerned.

Summary of Risk Factors

As part of this assessment, 26 risk factors were evaluated as to their importance in the conservation and recovery of fisher populations in the Sierra Nevada. Criteria applied in determining importance included the spatial extent, duration and timing, intensity, permanence, life cycle affected, and weight of evidence for each risk factor. One interesting result of the analysis was that three risk factors that contributed to the historical decline of Sierra Nevada fishers — trapping, predator control, and use of pesticides or other toxins — appear to pose little threat today. Other risk factors (e.g., hardwood management, hazard tree removal, fuelwood collection, slash pile burning, fire suppression, recreation, livestock grazing, impoundments and canals, utility corridors, and research activities) also appear to pose little or no risk concerns based largely on spatial extent or intensity, while some factors, such as wildland fire management may prove beneficial to fisher populations. Finally, underburning may have short term negative impacts (e.g., initial loss of prey resources or decreased shrub cover), but greater benefits in the long-term (e.g., reduction of catastrophic fire risk).

However, ten risk factors are deemed important enough to be addressed further in Conservation Options. We should first recognize three essential steps towards Sierra Nevada fisher conservation. The first is the conservation of extant populations in the region, but not only the southern Sierra Nevada population, ostensibly the source population for natural dispersion into unoccupied areas elsewhere in the Sierra Nevada, but populations in the Klamath region (outside the scope of this assessment) as well that might be used in reintroduction programs. The second is to identify limitations to natural dispersal, including barriers or marginal habitat, while the third is the identification of areas of suitable habitat where reintroduction attempts are most feasible. There are ten important risk factors related directly to one or more of these steps. **Group selection**, **thinning**, and **salvage harvest** may be of low risk at the local level, but needs to be evaluated at the landscape level to ensure the habitat loss from these practices don't reach unacceptable levels in the framework of habitat conservation. Similarly, **DFPZ**s may have little impact to fishers based on the elevation zones they typically occur, but should be evaluated to ensure these areas of reduced cover do not pose barriers to fisher dispersal. **Even-aged management** is generally not practiced on Forest Service lands, and as such poses little threat to fishers on government lands. However, even-aged management is the primary silvicultural practice on regional industrial forests, some of which support fisher populations. Understanding how these fishers utilize industrial forests is important to ensure these populations survive, especially if they become source populations for future reintroduction attempts in the northern Sierra Nevada. There is also a risk of decreased canopy cover from trees killed by insects and disease, which concomitantly increases fire hazard and risk.

Highways are risk factors where they act as a barrier to fisher dispersal, or are a source of additive mortality (**Road Mortality**). **Disease** is another mortality factor that is worthy of future investigation based on recent studies in northern California (WCS 2006) showing disease occurrence may be more prevalent than generally thought for this solitary mustelid. Finally, **catastrophic wildfire** is an obvious risk factor given its potential to destroy large expanses of suitable fisher habitat, and the

predictions for wildfire risk to increase in the future as a result of **climate change** (Lenihan et al. 2006). In general, predicted habitat changes as a result of climate change in the Sierra Nevada may bode well for Sierra Nevada fishers by expanding mid-elevation habitat types used by fishers and reducing snowfall. However, as mentioned above, the simultaneous prediction of increased catastrophic wildfire may limit fishers' ability to benefit from habitat expansion.

Fisher Envirogram

An envirogram is a conceptual tool developed by Andrewartha and Birch (1984) as part of their theory of the environment. It illustrates the ecological context of a species and the factors that pose risks to individual survival and reproduction, as well as population viability. The animal and the factors that directly affect the population are included in the centrum. These factors are organized in four groups: resources, mates, predators, and malentities (including competitors). Indirect factors are included in the web, with progressively more indirect effects appearing on the left side of the envirogram.

The envirogram is an attempt to recognize the factors limiting population size, including both biotic and abiotic factors. The goal is to provide a format that allows the problems to stand out clearly. The pathways are hypotheses and are a useful guide for directing and prioritizing research. The individual hypotheses are that, if the levels of the factors were changed, the population would be affected. Envirograms are intended to be revised as research reveals the importance or lack of importance of the factors. Only the important components are retained. Figure 4 shows the envirogram prepared for the Sierra Nevada population of fishers with details of each factor described below.

Resources

Foraging habitat: Fishers ultimately do not select foraging habitat on the basis of tree species or forest structure, but rather on the availability of prey and the likelihood of successfully obtaining prey (Powell and Zielinski 1994). Foraging habitat requirements are more likely fulfilled in a wider variety of habitats than resting habitat requirements (Zielinski et al. 2004a). Factors that appear to affect foraging include canopy cover, basal area, and distance to water, with fishers using sites with higher canopy cover, higher basal area, and shorter distance to water than unused sites (Zielinski et al. 2006).

Natal and maternal dens: The natal dens located to date in California have been in cavities in large-diameter trees, including live and dead conifers and hardwoods (Truex et al. 1998, Higley and Matthews 2006). Maternal dens were also in large-diameter live trees and snags, although southern Oregon populations will also use logs (Aubry and Raley 2006).

Daily resting locations: In California, rest sites are most often found in large trees or snags, with logs, rock piles, and other ground cavities used less frequently (Truex et al. 1998, Mazzoni 2002). In trees and snags, rest sites tended to be in cavities, broken tops, and platforms formed by nests and witches brooms resulting from dwarf mistletoe (Truex et al. 1998, Mazzoni 2002). Hardwoods provide a large proportion of rest sites in the southern Sierra Nevada (Truex et al. 1998) and Douglas-fir (*Pseudotsuga menziesii*) was the most frequently used species by the North Coast and Klamath populations (Zielinski et al. 2004b).

Habitat in the vicinity of natal and maternal dens and daily resting locations: Fishers have stronger preferences for habitat in which to rest and den than in which to travel and forage (Powell 1993). Females appear to be more selective of habitat surrounding their rest sites (Zielinski et al. 2004b). Rest sites typically have dense canopies with large trees and snags nearby (Truex et al. 1998, Mazzoni 2002, Zielinski et al. 2004b). Tree canopy closure appears to be important at the landscape scale as well (Carroll et al. 1999). Large-diameter hardwoods, a multi-layered, high-volume canopy, and large-diameter logs

appear to be important characteristics of rest sites for the southern Sierra populations (Mazzoni 2002, Zielinski et al. 2004b). Rest sites in the southern Sierra Nevada were also characterized by habitat features that contribute to cool microclimates, such as steep slopes and short distances to water (Mazzoni 2002, Zielinski et al. 2004b).

Food: Fishers probably select prey on the basis of their availability and their diets are diverse (Heinemeyer and Jones 1994). The primary prey of fishers throughout most of their range are snowshoe hares (*Lepus americanus*), porcupines (*Erethizon dorsatum*), and carrion (Powell 1993), especially in the north and east, but these primary prey species are absent or rare in California (Golightly et al. 2006). Constituents of fisher diets in California include moles, sciurids, woodrats, mice, marmots, mountain beavers, quail, grouse, false truffles, plant material, deer carrion, and other small vertebrates, particularly lizards (Grinnell et al. 1937, Grenfell and Fasenfast 1979, Zielinski et al. 1999, Golightly et al. 2006). Porcupines may have been important prey prior to eradication campaigns (Grinnell et al. 1937). Large hardwoods may be important as sources of mast that may stimulate higher prey densities (Yeager 2005).

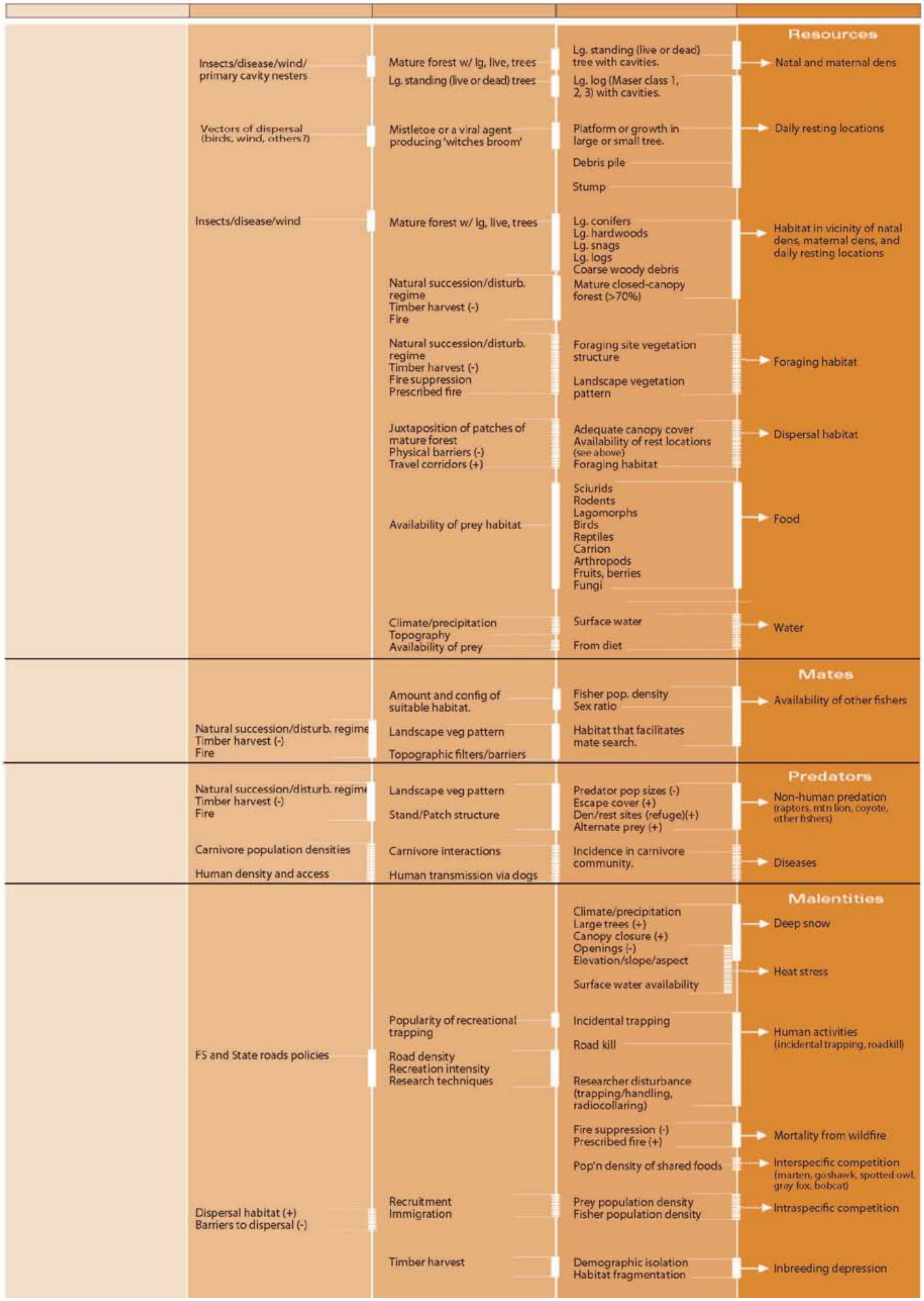

Figure 4. Envirogram developed for the Sierra Nevada fishers (*Martes pennanti*)

Water: In California, fishers are often found close to streams (Mazzoni 2002, Zielinski et al. 2004b), yet it is not clear whether this is related to prey distribution, availability of large trees used as rest sites, availability of water, or microclimate effects (Mazzoni 2002). Fishers are closely associated with riparian habitat in some regions (Heinemeyer and Jones 1994) including British Columbia (R. Weir, pers. comm.), but our knowledge of the importance of riparian habitat to California fishers is incomplete.

Mates

Availability of other fishers: In small populations, finding a mate may become increasingly difficult as population density decreases. This consequence, known as the Allee effect, may increase a small population's risk of extinction (Courchamp et al. 1999). Many mustelids are only in estrus for short time periods (e.g., only one day in American badgers [*Taxidea taxus*; Minta 1993]), so factors such as adequate travel corridors that facilitate finding mates will improve an individual fisher's chance of reproducing.

Predators

Non-human predation: Although fishers are rarely killed by non-human predators in eastern North America (Powell and Zielinski 1994), natural mortality may be higher for western fisher populations (Heinemeyer and Jones 1994). Predators of California populations likely include coyotes, mountain lions (*Puma concolor*), and raptors (Truex et al. 1998). Intraspecific predation may also occur (Heinemeyer and Jones 1994).

Diseases: Fishers generally exhibit low incidence of diseases, although diseases found in fishers include sarcoptic mange, Aleutian disease, leptospirosis, toxoplasmosis, and trichinosis (Powell 1993). Also, recent studies on the Hoopa Valley Reservation (Brown et al. 2006) have found the presence of potentially lethal West Nile virus, canine distemper virus, canine adenovirus, canine herpes virus, parvovirus, and an 87 percent exposure to *Anaplasma phagocytophilum*, a tick-borne infectious agent for granulocytic anaplasmosis, in 53 northern California fishers tested, suggesting disease may play a larger role than originally thought.

Human predation: Historically, trapping played a significant role in the declines in abundance of this species (Powell 1993). Trapping has been banned in California since 1946, although levels of poaching are unknown, and some individuals are harvested on the Hoopa Valley Reservation (M. Higley, pers. comm.). Even small changes in mortality due to trapping may affect population size (Powell 1979, Powell and Zielinski 1994). Road development can increase human access to remote areas, and this often coincides with greater levels of poaching in previously inaccessible regions (Thompson et al. 1998). Roads, and vehicle traffic on them, can also be a direct and important source of mortality (Truex et al. 1998).

Malentities

Deep snow: Deep snow is thought to limit fisher mobility, and this has been proposed as a possible explanation for the upper elevational limit of fisher distribution in the Sierra Nevada (Krohn et al. 1997). Fishers tend to avoid areas lacking overhead cover, and such areas tend to have greater snow depths.

Heat stress: Analysis of fisher rest sites in the southern Sierra Nevada indicates that animals select sites with the coolest microclimates (Zielinski et al. 2004b). Anecdotal evidence suggests that captive animals seek out shade on warm days (R. Golightly, pers. comm.).

Mortality from wildfire: Fishers evolved in forests that experienced fire and direct mortality due to fire is believed to be rare for most vertebrate species (Lawrence 1966, Dickson 1981, Quinn 1994). Negative effects from fire are more likely to result from localized changes in habitat and prey density.

Interspecific competition: Fishers are part of a suite of predators, each of which uses food resources in a slightly different way. Potential competitors of fishers include coyotes, bobcats, lynxes, gray foxes, red foxes (*Vulpes vulpes*), martens, wolverines, and weasels (*Mustela* spp.; Powell 1993). Fishers and martens are the only medium-sized predators that are agile in trees and able to explore burrows and other constrained sites (Powell 1993). Fishers are larger than martens and able to take a larger range of prey (Powell 1993).

Intraspecific competition: Researchers have observed cases of male-male aggression during the breeding season (Leonard 1986); however, this may not be as significant a factor at other times of the year due to the spacing patterns of male fishers.

Inbreeding depression: Habitat fragmentation may subdivide continuous populations and restrict gene flow (Lande 1999). Once a larger population is subdivided, the resulting small, isolated populations are more susceptible to the effects of genetic drift and the expression of deleterious recessive alleles (Lacy 1997). In California, fishers currently occur in two populations isolated by over 400 km, one occupying the Klamath and north coast regions of northwestern California and one occupying the Sierra Nevada south of and including Yosemite National Park (Zielinski et al. 1995) with effectively no gene flow between. Further, genetic research by Wisely et al. (2004) has found that the southern Sierra population has low genetic diversity, high genetic structure, and low levels of gene flow, characteristic of a small isolated population.

Researcher disturbance: Capturing and handling animals, marking them with ear tags, and fitting them with radio collars pose risks to individual animals. These activities can potentially influence their behavior (biasing research results; Powell and Proulx 2003) and affect their reproductive success and survival. Baited detection stations may also influence behavior requiring a caveat of caution when interpreting results. A recent review of the effects of marking on vertebrates found few impacts of tagging or radio-marking on mammals (Murray and Fuller 2000) although the literature contains few studies that scrutinize the potential impacts of these research methods. Powell and Proulx (2003) recently developed performance criteria for a variety of capturing and marking techniques that incorporate ethics and common sense.

Summary

The components deemed important in the envirogram analysis match well with the risk factors analysis in that the most important components for fisher survival are those most affected by the ten most important risk factors.

CONSERVATION OPTIONS

General Conservation Options

The intent of this section is to identify considerations or opportunities available that may assist in the conservation of the fishers in the Sierra Nevada. As stated earlier, the overarching goal of the fisher conservation strategy is to conserve and expand extant populations, both those in the Sierra Nevada that provide a source for natural dispersal into formerly occupied range and those outside the Sierra Nevada that may provide animals for future reintroductions, and to ensure barriers to dispersal and recovery in former ranges are identified and removed. Considerable attention in the form of the CBI Fisher Baseline Project is currently focused on characterizing habitat use in the southern Sierra Nevada fisher population. Studies are underway to better quantify habitat use on industrial forests in the Klamath region. These studies represent the first step towards conservation and recovery of fishers across their historical range.

Understanding the extent, spatial arrangement, and connectivity of suitable fisher habitat in the Sierra Nevada is paramount to the conservation of extant populations (southern Sierra Nevada) and the successful reintroduction of populations to previously occupied areas (northern and central Sierra Nevada).

The results of studies to date have been described in previous sections of this assessment, and current and future work is being addressed in the Conservation Biology Institute's Southern Sierra Fisher Baseline Assessment. Consequently, the conservation options proposed here are focused on securing the extant fisher populations and reestablishing populations elsewhere in the Sierra Nevada, either through natural dispersal or reintroduction. Seven conservation options are proposed: 1) habitat rehabilitation and ecological restoration, 2) mitigating negative anthropogenic effects to fishers, 3) a landscape resistance assessment to identify both barriers to and corridors for dispersal from the southern Sierra Nevada fisher population, 4) support of continued research on industrial forest lands to identify potential source populations for reintroduction, 5) conduct a feasibility assessment for potential reintroduction (see Lewis and Hayes (2004) for an excellent example), 6) continue to support landscape level carnivore detection surveys, both as a means to document range expansions from extant populations or as measure of success for reintroduction programs, and 7) investigation of management effects to fisher behavior, vital rates and habitat use. Each is discussed below in further detail.

Habitat Restoration

Natural recovery and long-term maintenance of fisher populations in the Sierra Nevada will require a series of fisher population centers, inter-connected by areas of habitat suitable for dispersal. In some areas, extensive wildfires have eliminated this connecting habitat. These areas will require a strategic plan for restoring tree species composition, structure, and ecological functions to support establishment of fisher home ranges and/or movement corridors.

In some cases, such as the Tahoe National Forest vicinity, most of the potentially suitable fisher elevations occur below and beyond NFS boundaries. Management of private and commercially owned lands will play a major role in restoration of fishers to this area. Conservation options, easements and incentives should be examined and pursued through the state and FWS.

Amelioration of Negative Anthropogenic Effects

Mortalities that occur as a result of the highly developed olfactory sense of fishers and their ability to enter into relatively small openings to become trapped can easily be mitigated once discovered.

Openings can be covered (standing drainage pipes) and/or exit ramps provided in water catchments. If certain stretches of highways have high fisher mortality rates, installation of over- or under-passes can be investigated to safely move the species across the roads. Effects of OHV on fisher need to be investigated and mitigated if found to be a threat.

Landscape Resistance and Habitat Suitability Assessment

Recovery of fisher populations in the Sierra Nevada requires two basic sets of information: 1) where do they presently occur and where have they been extirpated (and, therefore, where they could be reintroduced), and 2) what are the extent, spatial arrangement, and connectivity of suitable habitat (Schadt et al. 2002). The combination of the two sets of information assist conservation biologists in determining where to expend effort to conserve existing populations, and to identify candidate locations for reestablishing new populations. The first set of information is largely available from the Sierra Nevada carnivore detection studies (Zielinski et al. 1997b, 2000). Conserving existing populations is vital because it provides both a source for establishing new populations and a reservoir of the vital information (e.g., basic ecology and habitat use) needed to effectively conserve and reestablish populations. Conservation of existing populations in the Sierra Nevada is further being addressed under the Southern Sierra Fisher Baseline Assessment, while assisting in the conservation of extant populations outside the Sierra Nevada (potential reintroduction source populations) is addressed in the following Conservation Option. The second set of data — the extent, spatial arrangement, and connectivity of suitable habitat — has not been collected. These data will be used to identify gaps in habitat connectivity, which will inform efforts to translocate fishers or assist the expansion of the existing population (e.g., by removing barriers).

Specific to the Sierra Nevada, translocating animals from outside Forest Service lands may be a last resort option given the cost, logistical, genetic, and legal implications. A more cost-effective option would be to secure the existing population in the southern Sierra Nevada and allow this population to expand northward eventually reoccupying suitable habitat in central and northern Sierra Nevada. However, northward expansion depends on the availability of patches of suitable habitat and travel corridors linking these patches. By assessing the matrix of suitable habitat and corridors in the Sierra Nevada, including assessing barriers to dispersal such as rivers, highways, and open forest areas, one could predict fisher movements northward and determine what barriers to northward expansion might require management actions to resolve. Basically, the assessment evaluates the resistance, or conversely the permeability, of the Sierra Nevada landscape to natural northward dispersal by southern Sierra fishers. This approach has been followed for assessing reestablishment of Eurasian lynx populations in Germany (Schadt et al. 2002) and the expansion of grizzly bear (*Ursus arctos*) populations in the Rocky Mountains (Boone and Hunter 1996). See Singleton et al. (2002) for their work in Washington on least cost pathways for carnivores.

While more than one method can be used to assess the spatial arrangement of suitable habitat, the rule-based assessment approach described by Schadt et al. (2002) is a good example of an approach used specifically to address reestablishment of a mesocarnivore (Eurasian lynx [*Lynx lynx*]) into its former range. In this approach, available information on habitat use by fishers is used to establish "rules" related to fragmentation of habitat patches, barriers, minimum patch size, core areas, and minimum forest cover, which become the basis of a habitat model for quantifying suitable habitat using GIS. Then, using a cost-path analysis approach, a patch connectivity model is developed that quantifies the effectiveness of the connected patch network. The final outcome is a visual model identifying permeability and resistance in the Sierra Nevada landscape to the ability of fishers to disperse to currently unoccupied suitable habitat. Schadt et al. (2002) used this approach to develop management

strategies for improving connections to patches of suitable lynx habitat as well as identify locations where reintroduction projects might have the best opportunity for success.

Support for Fisher Research

It is not the Forest Service's purview to provide financial support for wildlife research on non-government lands. However, as a stakeholder in the recovery of fisher populations in California, the Forest Service has a vested interest in ensuring there is a viable source population upon which to draw individual fishers for reestablishing populations in the Sierra Nevada. One objective of the following Fisher Reintroduction Feasibility Assessment is to determine if there is a suitable source population for reintroduction. Presently, there is not enough information on the genetics, habitat use, and size of fisher populations inhabiting industrial forests to establish whether suitable source populations occur there. Yet, enough is known about these populations to suggest they offer the best potential as a reintroduction source population.

Current research on industrial forests in the Klamath region suggests that these forests support persistent fisher populations. However, the viability of these populations is unknown. Key unanswered questions include 1) how are fishers using these forests such that they continue to persist, 2) how viable are these populations (stable, declining, growing), 3) what is the genetic relationship of these fishers to fishers that previously inhabited the central and northern Sierra Nevada, and 4) is the population large enough to withstand the removal of the number of fishers needed to successfully establish a population in the Sierra Nevada?

The Forest Service's role with this Conservation Option is probably in an inter-agency team capacity. The inter-agency team would work closely with industrial forests biologists to help direct research towards answering the key questions above, and assist in finding funding for conducting these key studies. Working with cooperatively with industrial forest concerns may be the last best chance for conservation and recovery of fishers in California.

Fisher Reintroduction Feasibility Assessment

Like the central and northern Sierra Nevada, Washington State once supported populations of fishers that have since been extirpated. For Washington State, reintroduction might be the only viable choice for reestablishing fisher populations there because of the lack of suitable source populations close enough to naturally reestablish fishers in the state. Because it is possible that a fisher translocation might be the only effective means of reestablishing fisher populations in the northern half of the Sierra Nevada as well, a reintroduction feasibility assessment is appropriate.

Lewis and Hayes (2004) provide a feasibility assessment model fully applicable to the Sierra Nevada. The objectives of their present assessment are:

- Determine if an adequate amount and configuration of suitable habitat exists to support a population of fishers (see Landscape Resistance and Habitat Suitability Assessment),
- Determine if adequate prey exists to support a fisher population,
- Determine if there is a genetically suitable source population for reintroduction (see Off Forest Fisher Research Support),
- Assess the potential ecological impacts of reintroducing fishers on other species of concern,

- Identify elements needed to implement a reintroduction program,
- Determine the legal requirements for the capture and translocation of fishers, and
- Identify expected stakeholders and cooperators, and discuss potential implications of a reintroduction.

Paraphrasing Lewis and Hayes (2004) "A reintroduction would be deemed biologically feasible…if suitable foraging, denning, and resting habitat exist in forested landscapes in amounts and spatial configurations that are likely to support a self-sustaining fisher population; and if an adequate number of fishers from a genetically suitable source population are available. Social, political, and economic factors also need to be addressed for a reintroduction to be successful, but these are not factors that determine biological feasibility." Conducting a reintroduction feasibility assessment may require initiating a number of supporting studies (e.g., site-specific prey and habitat feature surveys). These potential research projects are not listed here, but would be developed within the framework of the feasibility assessment. Because preparation of the feasibility assessment and conducting associated studies will take time, this assessment should begin as soon as possible before the window of recovery of this species closes.

Landscape Level Carnivore Detection Surveys

Carnivore detection surveys at the landscape level have been conducted in the Sierra Nevada since 1996 (Zielinski et al. 2000). These surveys have provided a wealth of information on the current distribution of mesocarnivores. In particular these surveys have illustrated the extent of fisher decline in the Sierra Nevada. The main objectives of the surveys are to 1) describe the geographic range of fishers and other mammalian carnivores in the region, 2) collect data to develop and test regional habitat models for fishers and other carnivores, 3) provide baseline data for monitoring changes in population status for these carnivores, and 4) understand the influence and interaction of habitat factors, community ecological factors, and anthropogenic effects on the distribution of carnivores in the region. The information collected under Objective two and four provides foundation for the landscape resistance and habitat suitability assessment models described above, while continuation of Objective Three will provide a measure of success in fisher dispersal or reintroduction. Thus, a prime Conservation Option is to support continuation of these surveys into the future.

Investigate Management Effects on Fisher Behavior, Vital Rates, and Habitat Use

Assess effects of temporary disturbance to fishers denning, behavior, vital rates and habitat use. Consider and evaluate the effectiveness of limited operating periods in suitable denning habitat to avoid temporary disturbance to individual denning fishers and direct take of denning individuals.

Use landscape-level analyses to evaluate current ecological conditions to identify appropriate management techniques to meet multiple use objectives. Dispersal of juveniles in the extant population warrants investigation, as does the influence of landscape heterogeneity on fisher dispersal and population dynamics.

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